HOW **MICROPLASTICS** AFFECT YOUR BODY

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YOU SWALLOW EIGHT A YEAR IN YOUR SLEEP

THEY LAY EGGS UNDER YOUR SKIN

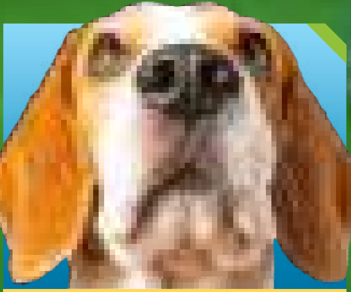
20 SPIDER MYTHS BUSTED

DADDY LONG-LEGS ARE HIGHLY VENOMOUS

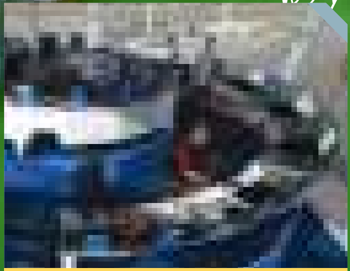
SPIDER SILK IS ANTIBIOTIC

NEWBORN INCUBATOR TECH EXPLAINED

SECRETS OF THE BOG PEOPLE



HOW FAR CAN DOGS SMELL?



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“Fear not, the world’s spiders do not intend to invade your home during the cold months”

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20 spider myths busted

PAGE 26

20 SPIDER MYTHS BUSTED

What’s that big hairy thing crawling across someone’s hand? It’s a tarantula, the poster child for arachnophobia and a much maligned member of the spider family Theraphosidae. Contrary to what many believe, tarantulas very rarely bite humans, even when handled, and while their venom causes some pain at the site of the wound, it’s often equivalent to a bee sting. In fact, this arachnid is considered so safe that some keep them as pets. In this issue of **How It Works**, we’re sorting common and often creepy spider myths from fact. Although as humans we’re hard-wired to shun these eight-legged creatures, they play a vital role in ecosystems all around the world. Enjoy!

Ben Biggs
EDITOR

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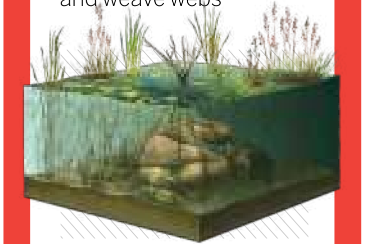

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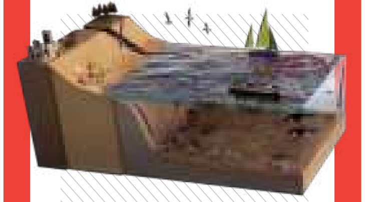

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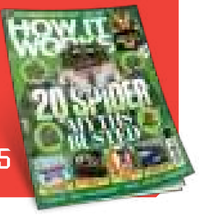

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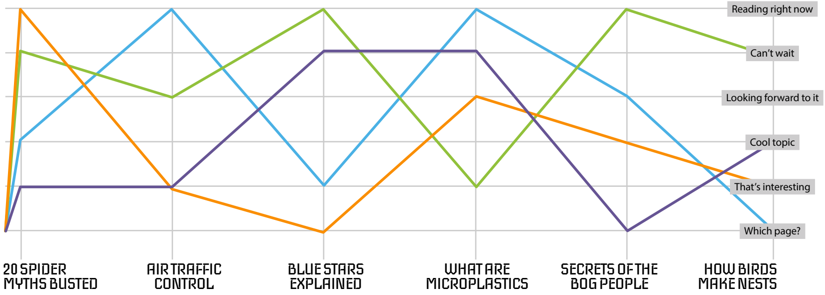

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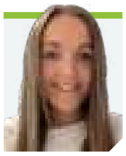

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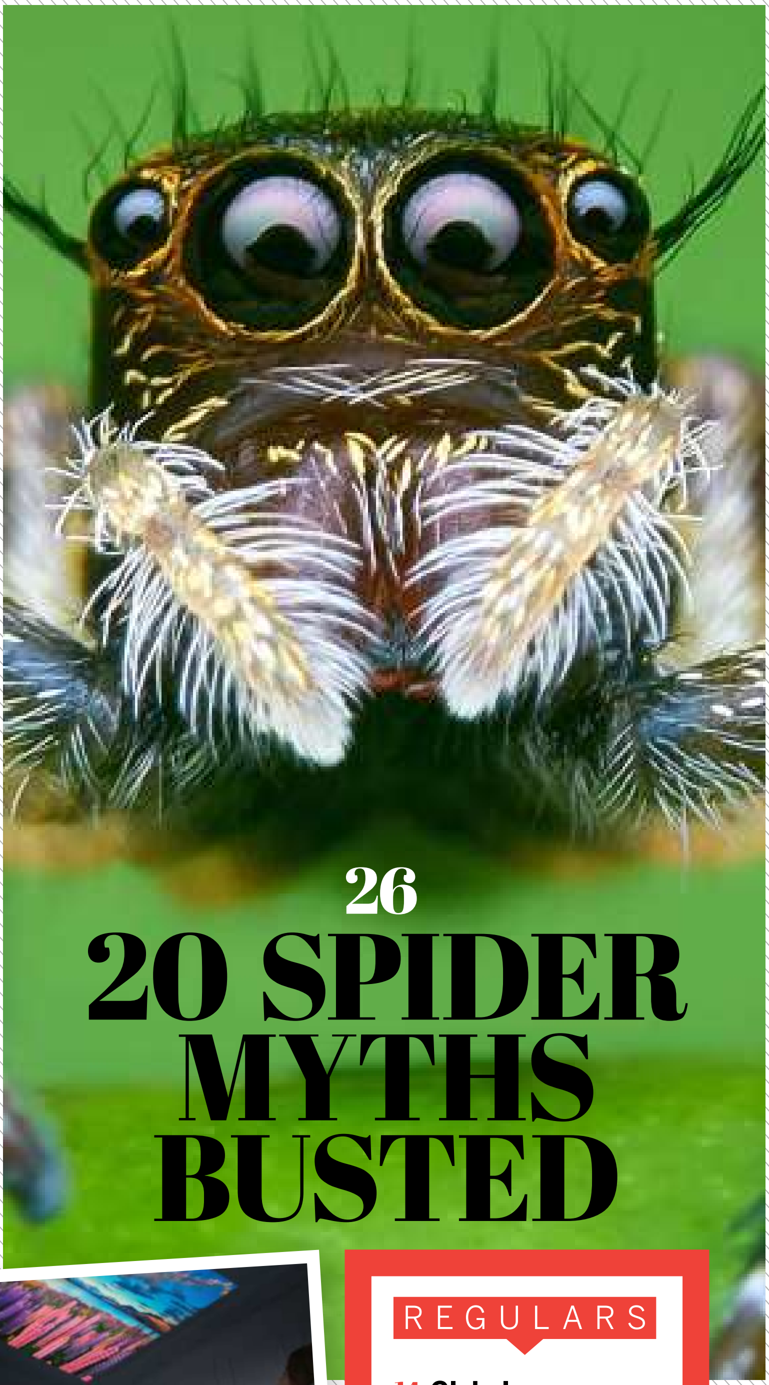

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20 SPIDER MYTHS BUSTED

Win!

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MEET THIS ISSUE'S EXPERTS

DR ANDREW MAY

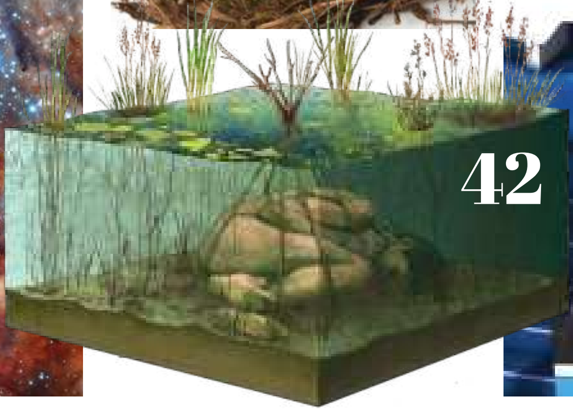
Andrew has a PhD in astrophysics and 30 years in public and private industry. He enjoys space writing and is the author of several books.

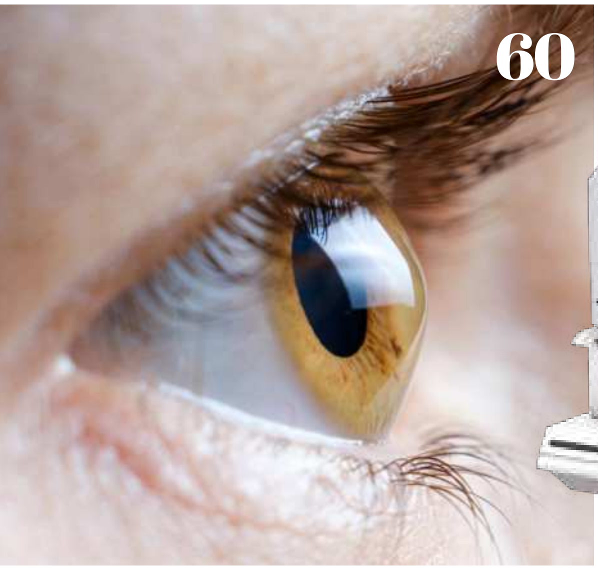
JACK GRIFFITHS

Former **HIW** staffer turned freelancer, Jack works in the medical industry and loves to escape on a science and technology press event.

ROBERT LEA

Robert is a science journalist who specialises in science, space, physics and astronomy. He has a bachelor of science in physics and astronomy.





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HOW IT WORKS
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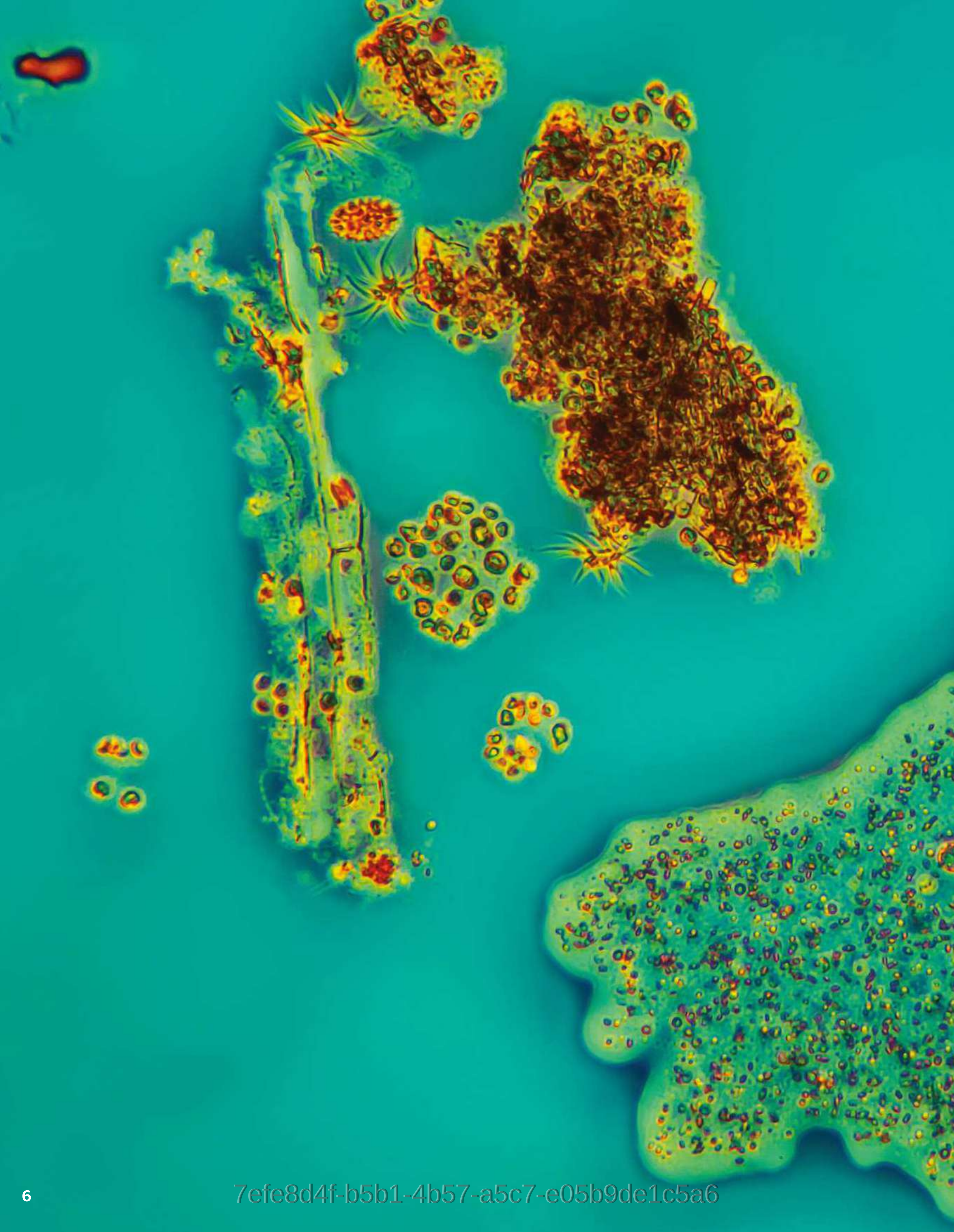

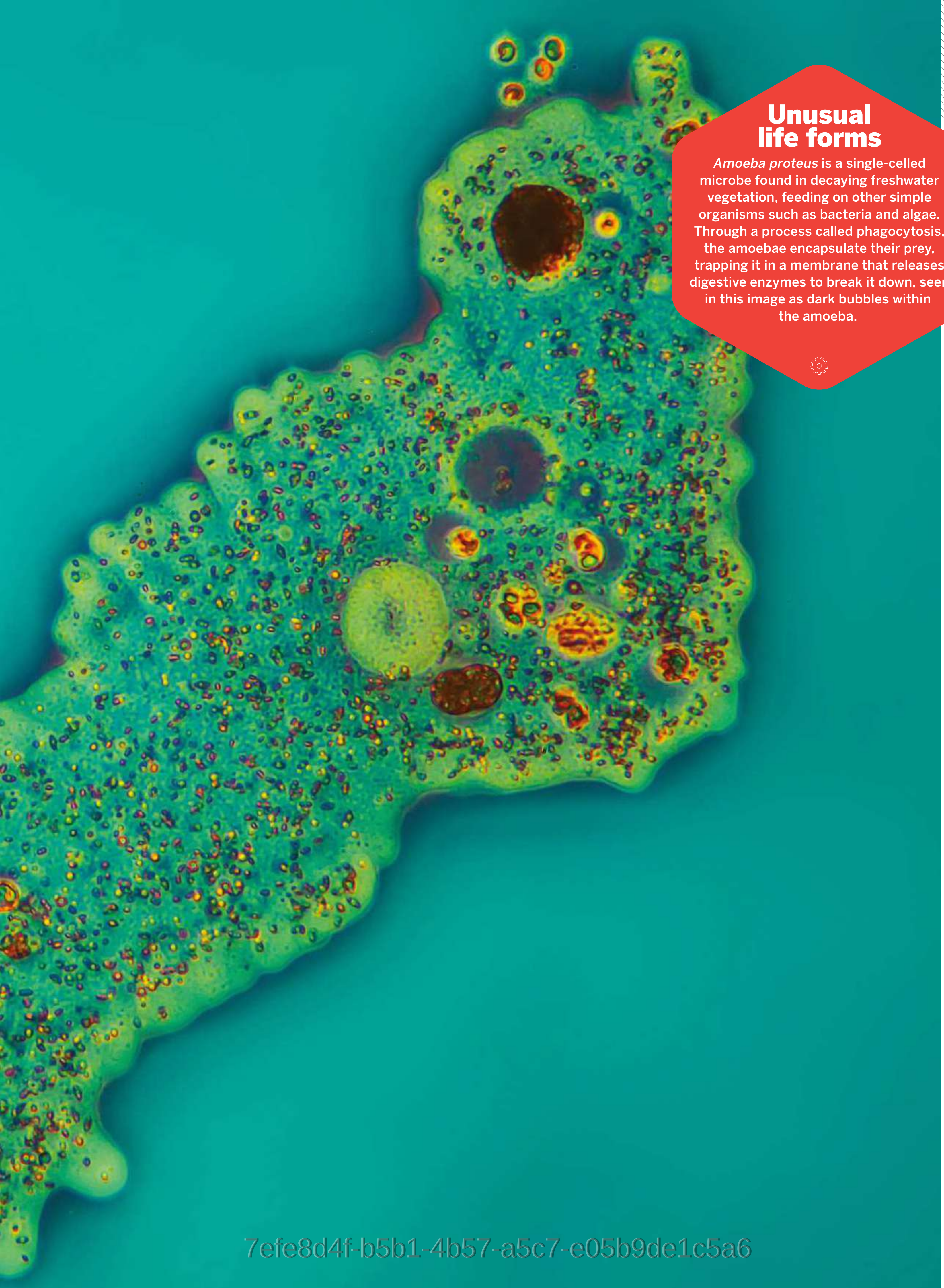

Unusual life forms

Amoeba proteus is a single-celled microbe found in decaying freshwater vegetation, feeding on other simple organisms such as bacteria and algae. Through a process called phagocytosis, the amoebae encapsulate their prey, trapping it in a membrane that releases digestive enzymes to break it down, seen in this image as dark bubbles within the amoeba.

© Alamy

Lurking on the seafloor

The bobbit worm, *Eunice aphroditois*, is a marine ambush predator that looks like something out of a horror film. Also known as sand strikers, these vicious predators can grow up to three metres in length, leaving only their mouthparts above the sand to await passing prey. When its sensitive antennae detect food, such as fish or shrimp, its strong jaw snaps shut so the worm can chow down.

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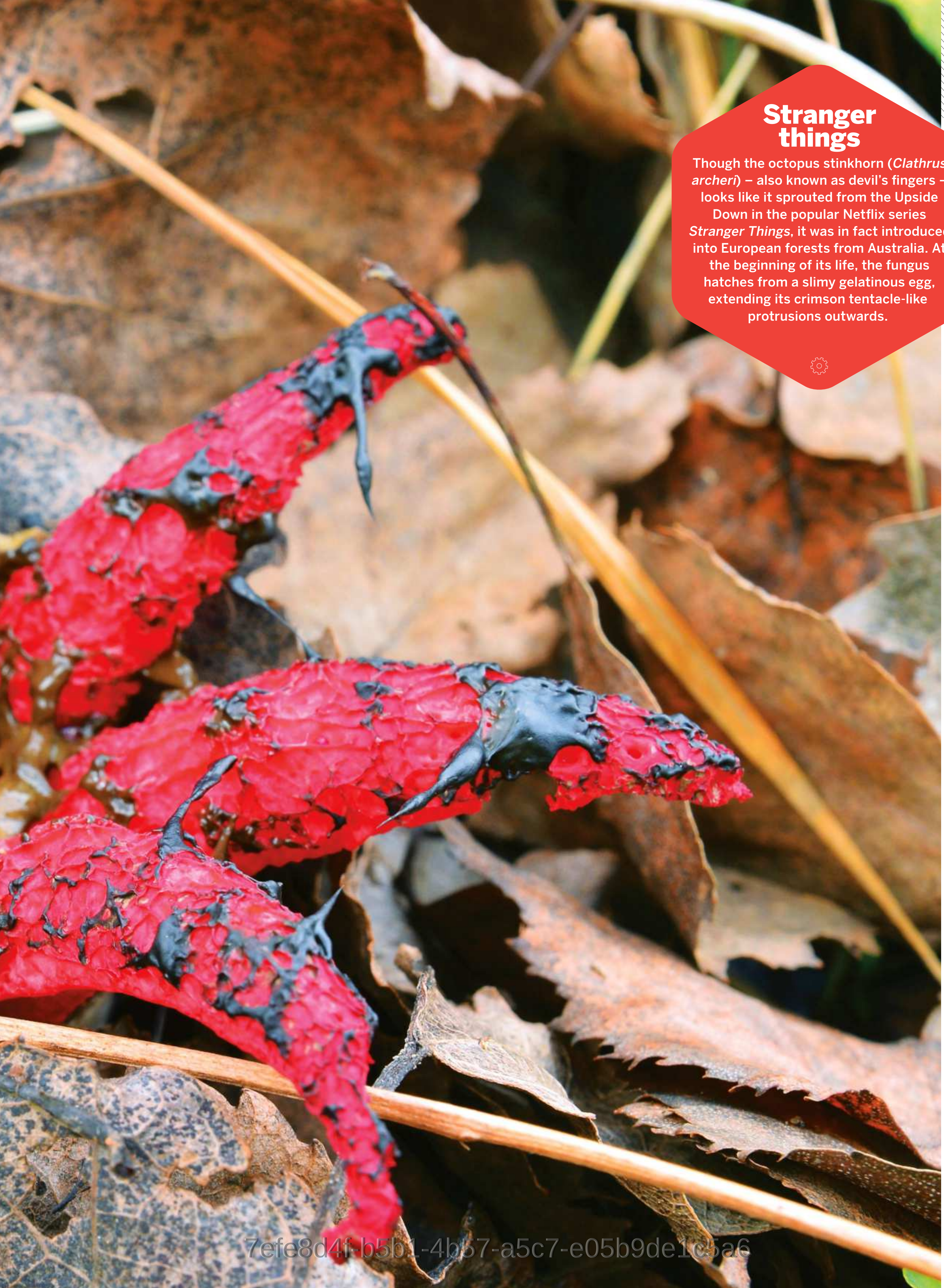

Stranger things

Though the octopus stinkhorn (*Clathrus archeri*) – also known as devil's fingers – looks like it sprouted from the Upside Down in the popular Netflix series *Stranger Things*, it was in fact introduced into European forests from Australia. At the beginning of its life, the fungus hatches from a slimy gelatinous egg, extending its crimson tentacle-like protrusions outwards.

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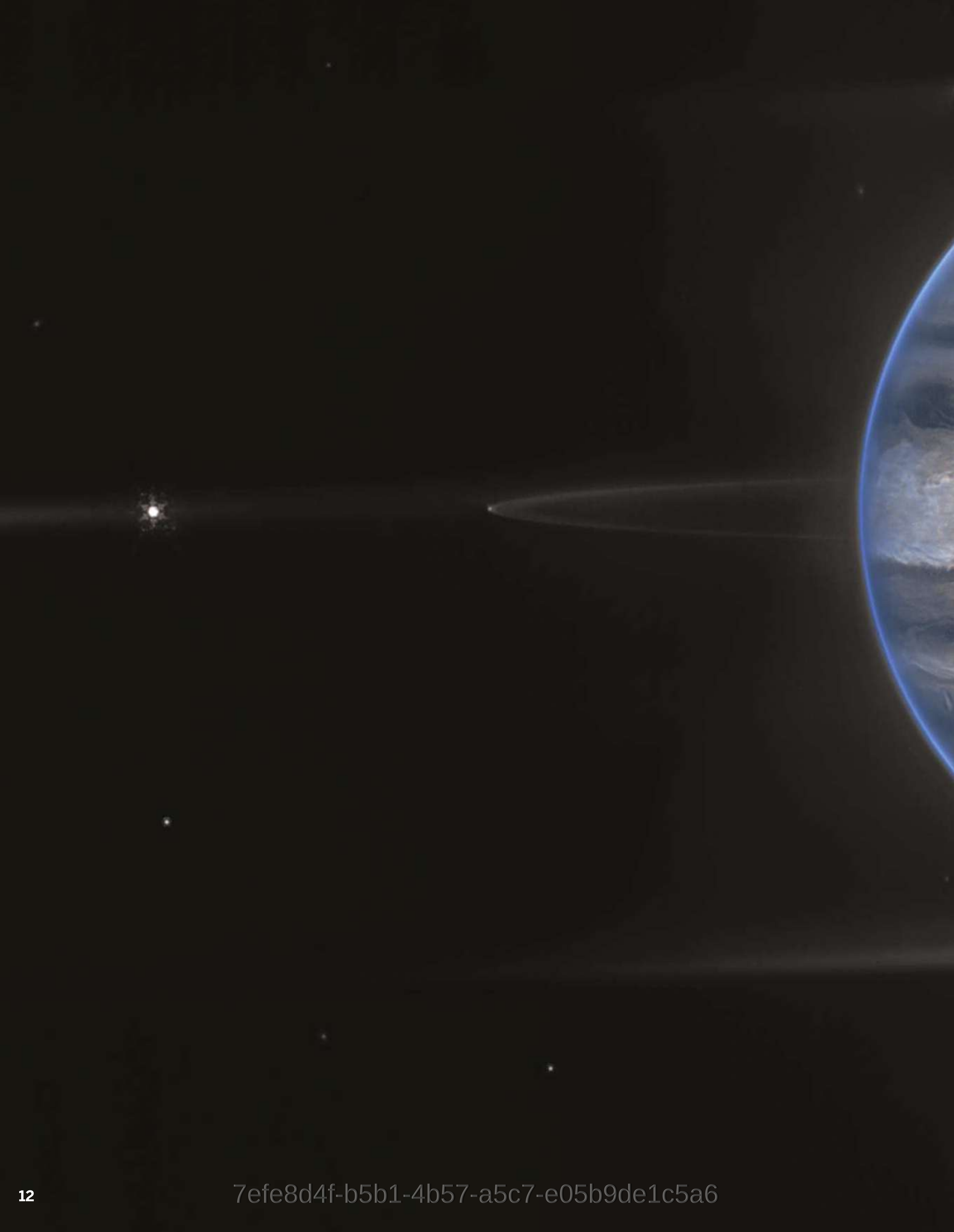
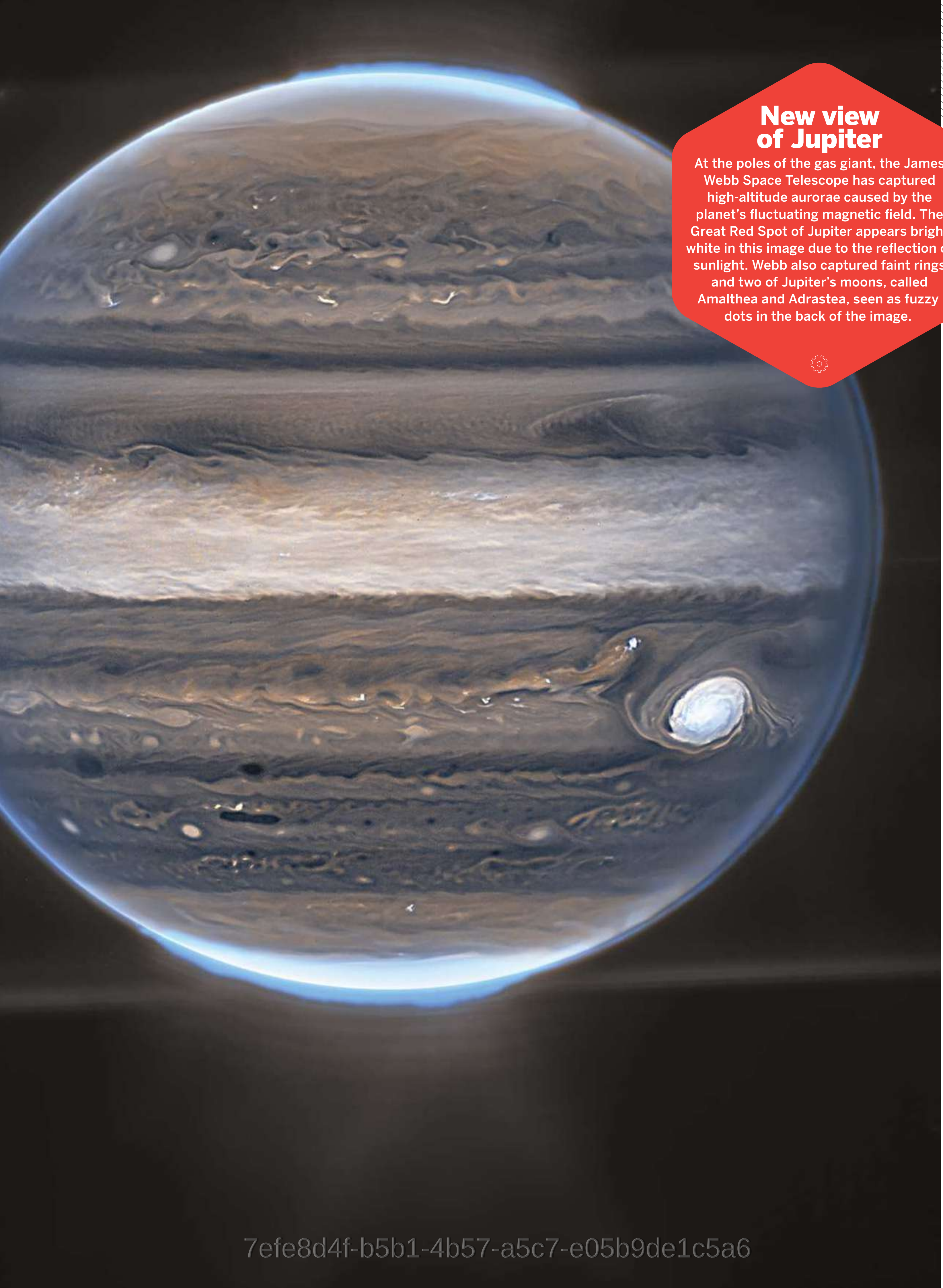
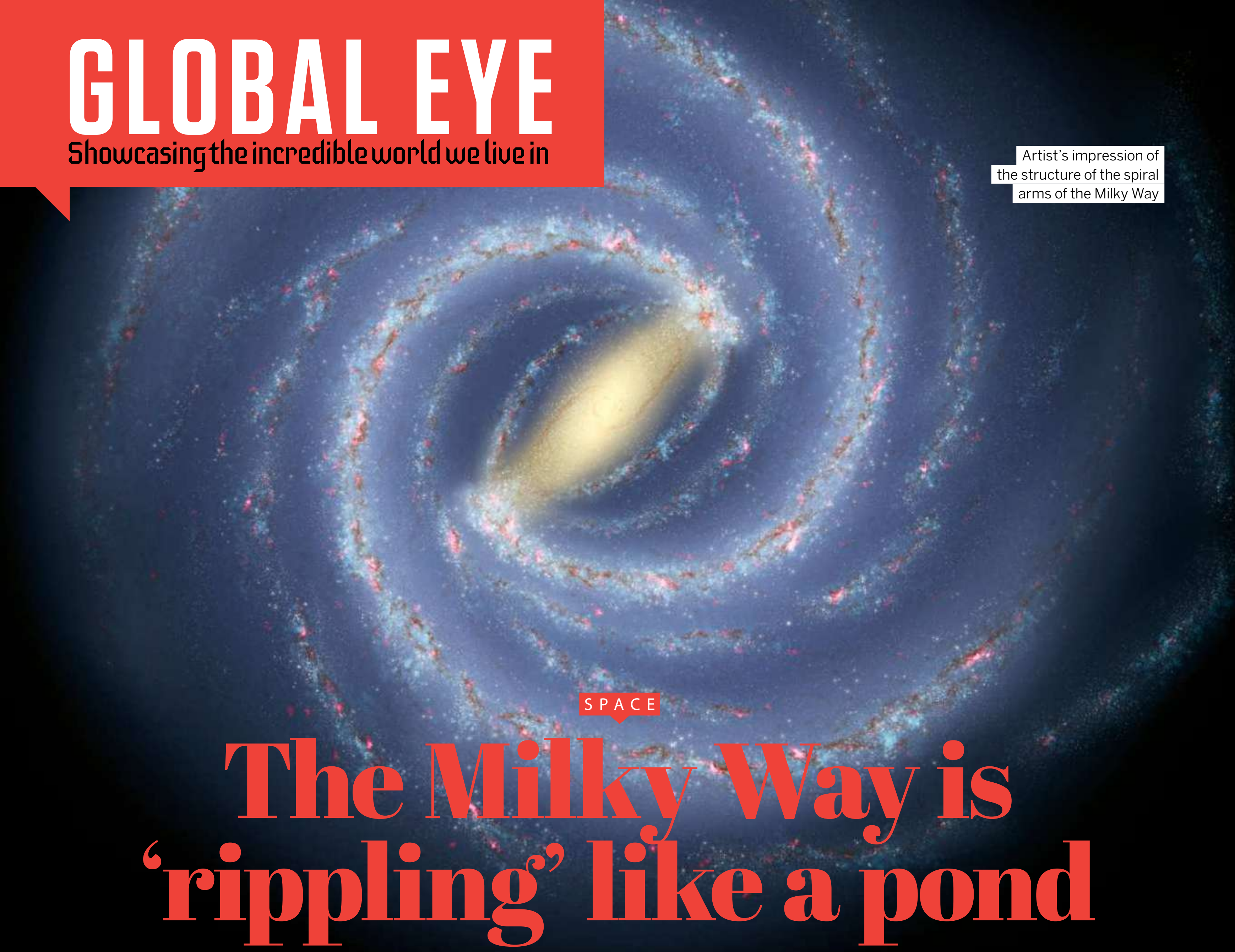




New view of Jupiter

At the poles of the gas giant, the James Webb Space Telescope has captured high-altitude aurorae caused by the planet's fluctuating magnetic field. The Great Red Spot of Jupiter appears bright white in this image due to the reflection of sunlight. Webb also captured faint rings and two of Jupiter's moons, called Amalthea and Adrastea, seen as fuzzy dots in the back of the image.

© NASA/ESA/CSA/Jupiter ERS Team/Ricardo Hueso (UPV/EHU)/Judy Schmidt



Artist's impression of the structure of the spiral arms of the Milky Way

SPACE

The Milky Way is 'rippling' like a pond

WORDS **BRANDON SPECKTOR**

Imagine the Milky Way's 100 billion stars as a flat, tranquil pool of water. Now picture someone dropping a stone the size of 400 million Suns into that water. The tranquillity is shattered. Wave after wave of energy ripples across the galaxy's surface, jostling and bouncing its stars in a chaotic dance that takes aeons to calm. Astronomers suspect that something like this may have really happened – not just once, but several times over the past several billion years.

In a recent paper, researchers explain how a nearby mini-galaxy – the Sagittarius Dwarf Galaxy – appears to have crashed through the Milky Way on at least two separate occasions, causing stars all around the galaxy to mysteriously oscillate at different speeds. Using data from the European Space Agency's Gaia space observatory, researchers compared the movements of more than 20 million stars located throughout the Milky Way, but particularly in the outer regions of the galaxy's disc. The data revealed a mysterious ripple, or vibration, that seemed to be jostling stars all throughout the galaxy. "We can see that these stars wobble and move up and down at different speeds," said Paul McMillan, an astronomer at Lund University in Sweden.

Through a process that the researchers equated to 'galactic seismology', the team modelled a wave pattern that could explain the strange ripple effect setting the Milky Way's stars off-kilter. They concluded that the ripples were likely released hundreds of millions of years ago when the Sagittarius Dwarf Galaxy last passed through our galaxy – "a little bit like when a stone is dropped into a pond," McMillan said. It seems likely that a second, even earlier collision between the two galaxies also occurred. Prior studies have suggested that an ancient collision with Sagittarius may have set off ripples at the Milky Way's centre, but this new research is the first to show that those ripples extended all the way to the edge of the galaxy's disc, perturbing stars every step of the way. This new research should help piece together the long and violent history of our galaxy and its smaller neighbour.

Today, the Sagittarius Dwarf Galaxy is estimated to be about 400 times the mass of Earth's Sun – a mere shrimp compared with the Milky Way's estimated mass of 1.5 trillion Suns. Scientists suspect that Sagittarius was once much larger, but lost up to 20 per cent of its mass to our galaxy after repeated collisions over the past several billion years. These collisions likely changed the shape and size of our galaxy too; a 2011 study suggested that the Milky Way's spiral arm is the result of two collisions with the Sagittarius Dwarf Galaxy. Another study of Gaia data released in 2020 suggested that cosmic crashes between our galaxy and Sagittarius triggered baby booms of new stars in the Milky Way every time the two galaxies met.

Did you know?

Astronomers think that the Milky Way has four main spiral arms

A new type of crystal, and a potential nuclear fusion fuel source, has been detected on the near side of the Moon

SPACE

RARE CRYSTAL DISCOVERED ON THE MOON

WORDS **BRANDON SPECKTOR**

Researchers in China have discovered a new type of crystal nestled among the volcanic debris of the near side of the Moon, as well as a potential fuel source that could help revolutionise the production of clean and efficient energy on Earth. The small, transparent crystal – named Changesite-(Y) after the Chinese Moon goddess Chang'e – is more than a billion years old and is as wide as a human hair. In early September, researchers with the International Mineralogical Association confirmed that the tiny Moon crystal has a never-before-seen composition and is related to other minerals found only on the Moon or in meteors.

Researchers collected the crystal among roughly 1.8 kilograms of lunar rocks in 2020 during China's Chang'e-5 mission. These rocks were the first lunar samples to be taken to Earth since 1976 and the first lunar samples ever collected by China. The Changesite-(Y) crystal's discovery marks the sixth new mineral to be identified on the Moon, and the first identified by China; the five previous discoveries were made by either the US or Russia. However, the teeny crystal was not the only remarkable find in the Chang'e-5 Moon rock haul. Among the roughly 140,000 lunar particles analysed, scientists also found traces of helium-3 – a version of the element helium that is exceptionally rare on Earth but is believed to be abundant on the Moon.

HEALTH

$3 million prize won for an AI that predicts every protein's structure

WORDS **NICOLETTA LANESE**

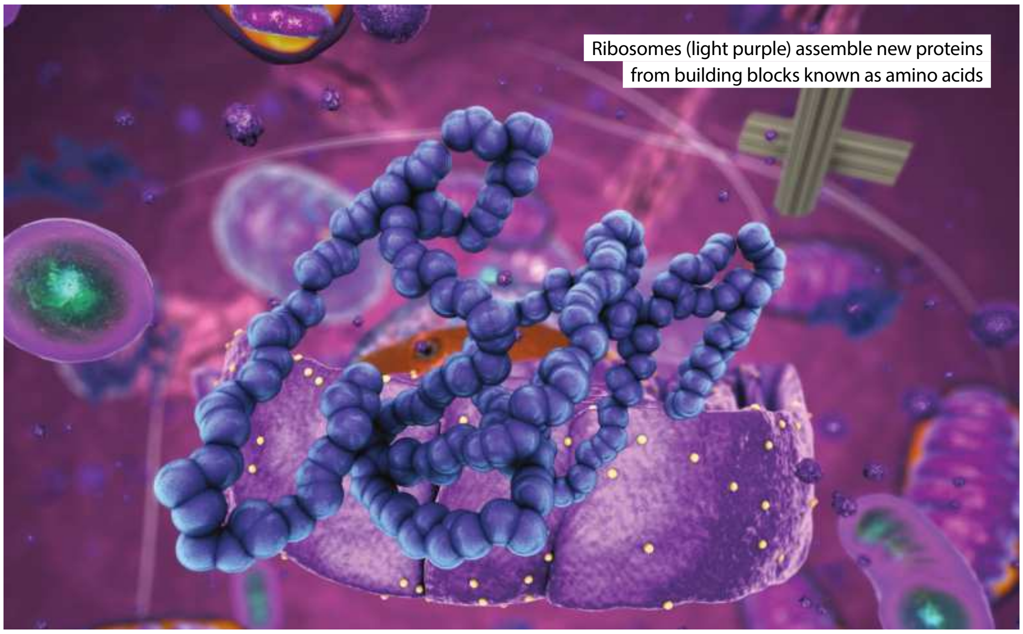
Scientists from Google DeepMind have been awarded a $3 million (£2.7 million) prize for developing an artificial intelligence (AI) system that has predicted how nearly every known protein folds into its 3D shape. One of this year's Breakthrough Prizes in Life Sciences went to Demis Hassabis, the cofounder and CEO of DeepMind, which created the protein-predicting program known as AlphaFold, and John Jumper, a senior staff research scientist at DeepMind.

The open-source program makes its predictions based on the sequence of a protein's amino acids, or the molecular units that make up the protein. These individual units link up in a long chain that then gets 'folded' into a 3D shape. The 3D structure of a protein dictates what that protein can do, whether that's cutting DNA or tagging dangerous pathogens for destruction, so being able to infer the shape of proteins from their amino acid sequence is incredibly powerful. The Breakthrough Prizes recognise leading researchers in the fields of fundamental physics, life sciences and mathematics. Each prize comes with an award, supplied by founding sponsors Sergey Brin, Priscilla Chan and Mark Zuckerberg, Yuri and Julia Milner and Anne Wojcicki.

"Proteins are the nanomachines that run cells, and predicting their 3D structure from the sequence of their amino acids is central to understanding the workings of life," the foundation's statement reads. "With their team at DeepMind, Hassabis and Jumper conceived and constructed a deep-learning system that accurately and rapidly models the structure of proteins." Using AlphaFold, the DeepMind team has compiled a database of some 200 million protein structures, including proteins made by plants, bacteria, fungi and animals. This database includes nearly all catalogued proteins known to science.

The AI system 'learned' to assemble these shapes by studying known protein structures compiled in existing databases. These protein structures had been painstakingly visualised with a technique called X-ray crystallography, which involves zapping crystalline protein structures with X-rays and then measuring how those rays diffract. Within these existing databases, AlphaFold identified patterns between proteins' amino acid sequences and their final 3D shapes. Then, using a neural network – an algorithm loosely inspired by how neurons process information in the brain – the AI used this information to iteratively improve its ability to predict protein structures, both known and unknown.

"It's been inspiring to see the myriad of ways the research community has taken AlphaFold," said Hassabis, "Using it for everything from understanding diseases, protecting honey bees, deciphering biological puzzles and looking deeper into the origins of life itself."



Ribosomes (light purple) assemble new proteins from building blocks known as amino acids

© Alamy / Getty / NASA/JPL-Caltech/ESO/R. Hurt

PLANET EARTH

Huge ancient lava flow seen from space

WORDS **HARRY BAKER**

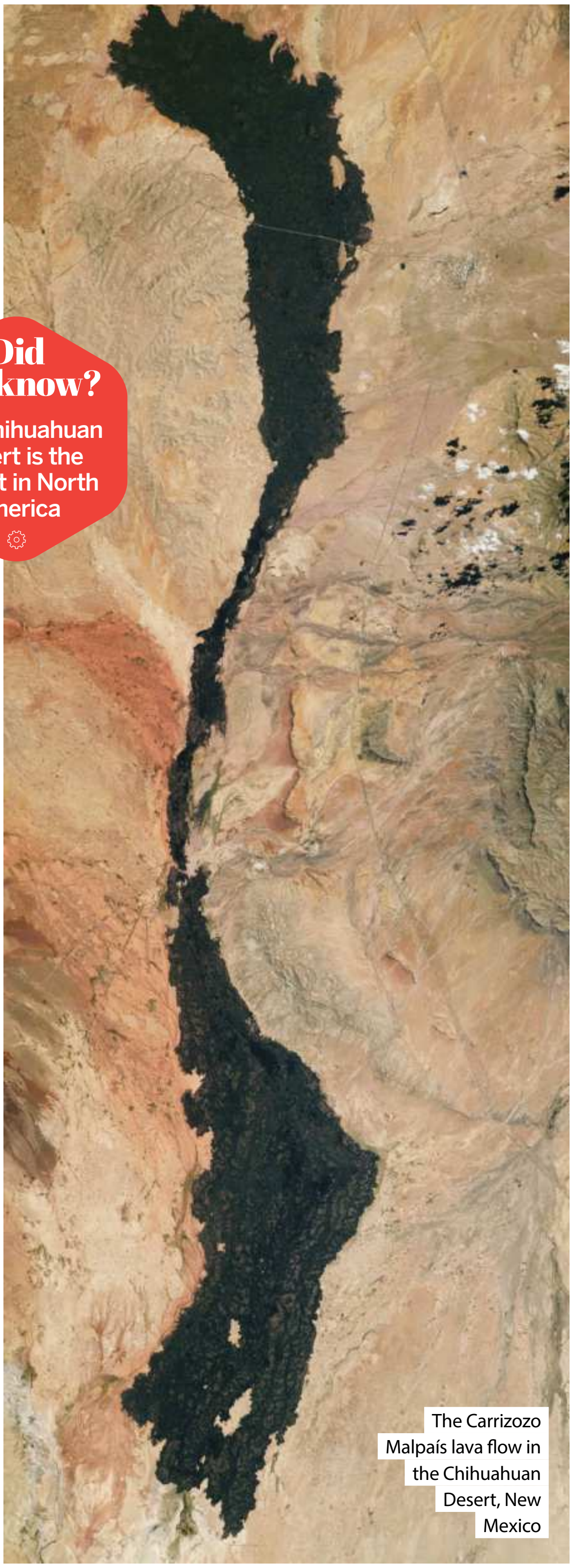
An astronaut aboard the International Space Station (ISS) has snapped a stunning photo of an ancient lava flow stretching across the desert in New Mexico. From above, the frozen river of volcanic rock looks like a dark scar carved into the surrounding desert. The basaltic lava flow, known as the Carrizozo Malpaís, covers around 130 square miles and is around 50 miles long. It's located near Carrizozo, a city in the Chihuahuan Desert in New Mexico, and is one of the largest lava flows to have formed on Earth in the past 10,000 years. The eruption that birthed the Carrizozo Malpaís began around 5,000 years ago and lasted for between 20 and 30 years. During that time, magma slowly trickled out of the ground from a subsurface shield volcano, which has since become dormant. Insulated lava tubes beneath the surface spread the molten rock out over an unusually large area.

The new image is a mosaic of four photographs taken on 30 June by an unidentified astronaut from the Expedition 67 crew on board the ISS. The majority of the lava in the image emerged from a small 27-metre vent that locals have dubbed 'little black peak', located at the north end of the lava field, on the left-hand side of the image. The vent sits in the middle of a zone of crustal weakness known as the Capitan lineament, where magma easily rises through Earth's crust and erupts on the surface.

The uneven and textured appearance of the frozen lava is the result of light scattering off fissures, collapses and depressions in the volcanic rock. A main road and railway also bisect the northern end of the lava field. The ancient lava field may seem lifeless from above, but a number of desert plant species – such as prickly pear cactuses, perennial flowers and juniper trees – can grow in the frozen magma.

Did you know?

The Chihuahuan Desert is the largest in North America



The Carrizozo Malpaís lava flow in the Chihuahuan Desert, New Mexico

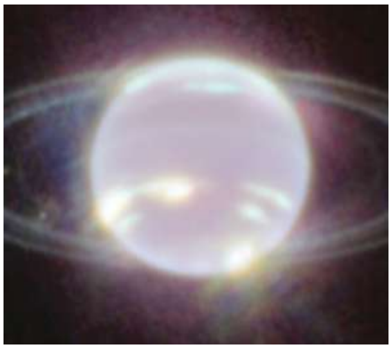
SPACE

GHOSTLY RINGS OF NEPTUNE SHINE IN NEW WEBB IMAGES

WORDS **BRANDON SPECKTOR**

When it comes to planetary rings, Saturn is the king. But now a new contender enters the ring, courtesy of a stunning image taken by the James Webb Space Telescope. Astronomers have known for decades that the ice giant, located about 30 times farther from the Sun than Earth, has five rings made chiefly of icy dust. The new image reveals those frigid rings in crisper detail than any survey since the Voyager 2 probe passed within a few thousand miles of Neptune in 1989. "In addition to several bright, narrow rings, the Webb images clearly show Neptune's fainter dust bands," researchers wrote. "Webb's extremely stable and precise image quality permits these very faint rings to be detected so close to Neptune."

Floating near the edge of our Solar System, Neptune is invisible to the naked eye. But in visible-light images taken by Voyager 2 and the Hubble Space Telescope, Neptune appears a striking blue. That colouration comes from methane in the planet's cloudy atmosphere, which likely stretches down to great depths within the planet before melding into a superhot ocean of melted ice, ammonia and other compounds. To Webb, which uses a special sensor to capture light at near-infrared wavelengths, those methane clouds shine eerily with reflected sunlight, giving the planet a more ghostly white appearance.



Neptune and its rings glow an eerie white in this new Webb image

An illustration of coronavirus particles

HEALTH

China approves first inhaled COVID-19 vaccine

WORDS BEN TURNER

China has approved the world's first inhaled COVID-19 vaccine, the vaccine maker CanSino Biologics (CanSinBIO) in Tianjin, China, has announced. The newly approved vaccine, named Convidecia Air, uses the same platform as the injectable COVID-19 vaccine by the same manufacturer – pieces of genetic material transported by a harmless adenovirus vector so the body can be trained against the virus. This vaccine, however, is inhaled through the mouth as a fine mist. China's National Medical Products Administration has approved the vaccine for use as a booster.

The needle-free vaccine is the first approved of over 100 oral or nasal vaccines currently in development around the world. Scientists hope that administering vaccines through the nose or mouth could prepare the immune cells of the thin mucous membranes there, preventing the spread of even mild cases of the illness by killing the virus as it enters the body. The self-administered dose "can effectively induce comprehensive immune protection in response to SARS-CoV-2 after just one breath," said CanSinoBIO representatives.

CanSinBIO already has an injected form of the same vaccine in use in China and approved in a few other countries. According to Phase III clinical trials, the injected vaccine was 57.5 per cent effective at preventing any COVID-19 symptoms and 91.7 per cent effective at preventing severe disease after four weeks or longer following a single administered dose. Another clinical trial showed the immunity levels produced by two inhalations of the vaccine 28 days apart reached the same as those produced by one intramuscular shot.

The new inhalable format is reminiscent of nasally administered influenza vaccines, such as the intranasal FluMist vaccine. As vaccines of this type target the lungs and upper airways where viruses like influenza and COVID-19 enter the body, scientists think inhaled vaccines could be much more effective at stopping the spread of infections and require much lower doses to do the same job. For instance, in a recent study of the Convidecia Air vaccine, two Sinovac shots followed by a lower dose inhaled vaccine produced detectable levels of omicron-neutralising antibodies in 92.5 per cent of cases, whereas a higher dose generated detectable antibodies in 88.9 per cent of cases. The number for both groups, however, dropped to around 70 per cent six months later.

Chinese regulators hope that the new delivery method will encourage more people to get vaccinated, such as those afraid of needles, but how impactful it will be in an already highly vaccinated population remains to be seen. China has distributed more than 3.4 billion vaccine doses to fully vaccinate 89.9 per cent of its population already, compared to 68 per cent of people in the US. Despite China's high vaccination rates, concern for China's healthcare system, which does not have widespread capacity for sudden patient influxes, and a dropoff in efficacy of China's vaccines over time has wedded the ruling Chinese Communist Party (CCP) to developing easily administered boosters alongside enforcing a strict zero-COVID policy.

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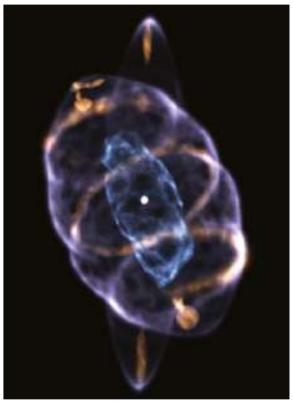
SPACE

A SECRET STAR AT THE CENTRE OF THE CAT'S EYE NEBULA

WORDS BRANDON SPECKTOR

When a star roughly the size of the Sun approaches the end of its life, it expels its outer layers of gas into a bright, beautiful bubble known as a planetary nebula. At the centre of each bubble, a weakened star irradiates its surroundings, sculpting the gas. One of the strangest of these cosmic clouds is the Cat's Eye Nebula, located about 3,000 light years from Earth. Seemingly made of several overlapping bubbles of blue gas with long, streamer-like filaments wrapped tightly around them, the nebula has defied clear explanation for centuries.

Using data from the San Pedro Mártir National Observatory in Mexico showing the movements of layers of gas in the nebula, astronomers created the first-ever 3D model of the Cat's Eye Nebula. Their map reveals a pair of perfectly symmetrical rings swirling around the entire length of the nebula's outer shell. According to the researchers, there's only one possible cause of these rings' symmetry: a double-barrelled burst of energy known as a precessing jet. As the nebula's central star died, it released twin bursts of high-density gas in opposite directions at the same time. But rather than remaining fixed in place, the jets began to wobble like a spinning top, leaving slowly looping rings of gas twirling above and below the star.



A 3D model of the Cat's Eye Nebula (above right) compared to a Hubble Space Telescope image (above)

HISTORY

A vanished arm of the Nile helped build the pyramids

WORDS OWEN JARUS

When the ancient Egyptians built the pyramids of Giza around 4,500 years ago, the Nile River had an arm – one that has long since vanished – with high water levels that helped labourers ship materials to their construction site. The discovery builds on previous archaeological and historical findings that the Nile had an extra arm flowing by the pyramids. But now, by analysing ancient pollen samples taken from earthen cores, it's clear that the former waterscapes and higher river levels gave the Giza pyramids' builders a leg up. New research sheds light on how the pyramids – royal tombs for the pharaohs Khufu, Khafre and Menkaure – rose to monumental heights. Their towering stature was achieved in large part thanks to the Nile's now-defunct Khufu branch, which "remained at a high water level during the reigns of Khufu, Khafre and Menkaure, facilitating the transportation of construction materials to the Giza Pyramid Complex," researchers wrote.

Researchers have known for decades that the long-gone Khufu branch extended up to the Giza plateau in ancient times, but the new project aimed to find exactly how the water levels had changed over the past 8,000 years. To reconstruct the Nile's past, in May 2019 the team drilled five cores into the Giza floodplain. The researchers measured the amount of pollen found in different parts of the cores to determine how pollen levels had changed over time. Time periods when water was plentiful should have more pollen than periods that were arid.

The pollen analysis revealed that at the time the ancient Egyptians built the Giza pyramids, water was plentiful enough that the Khufu branch would have flowed near the pyramid site. "It was a natural canal in the time of the Fourth Dynasty," said study member Hader Sheisha, a physical geographer at Aix-Marseille University in France. Sheisha noted that the water level was important for pyramid construction. "It would be very difficult, if not impossible, to build the pyramids without the Khufu branch and without it having a good level, which provides enough accommodation space for the boats carrying such heavy blocks of stone," she said.

When exactly the branch went extinct is not certain, but the research shows that by 2,400 years ago the water level of the branch was very low. The new findings fit well with previous archaeological finds, which revealed a harbour close to the pyramids, as well as ancient papyri records that detailed workers bringing limestone to Giza via boat.

Did you know?

Khufu was the second pharaoh of the Fourth Dynasty

New findings shed light on the Nile's water level at the time the Giza pyramids were built

Tardigrade survival attributed to proteins found in no other animals

WORDS **STEPHANIE PAPPAS**

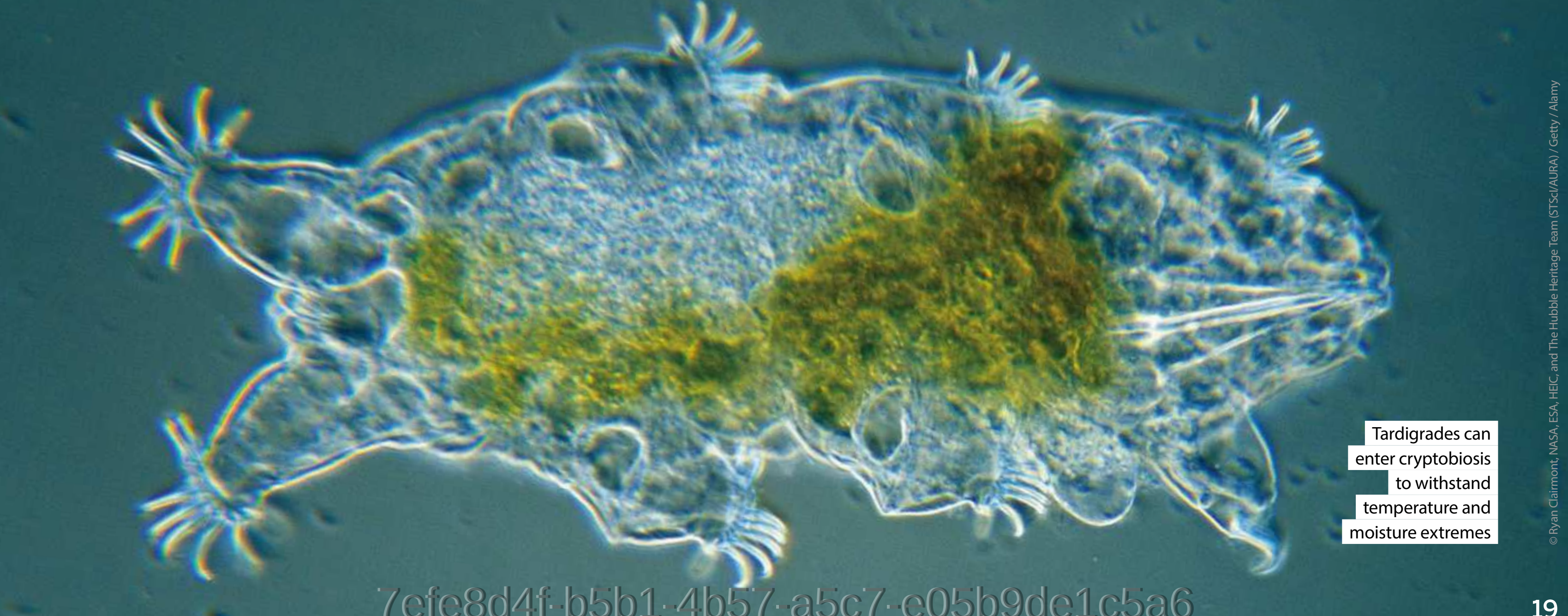
Tiny tardigrades can survive conditions that would kill most other forms of life. By expelling their body's water and turning into a seemingly lifeless ball called a tun, they enter a state of dried-up suspended animation in which they can survive for decades without food and water and withstand extreme temperatures, pressures and even the vacuum of space. However, little is known about what drives this protective mechanism and what keeps tardigrades from succumbing to the stresses of prolonged desiccation. Now, a new study reveals how tardigrades survive without any water at all: unique proteins turn the insides of tardigrade cells into gel, thereby preventing the critters' cell membranes from crinkling and collapsing. This strategy is completely different from those seen in other types of animals that can survive dry periods. In fact, "no such proteins have been reported in other desiccation-tolerant organisms," said Takekazu Kunieda, a biologist at the University of Tokyo.

Tardigrades, known as water bears or moss piglets, are a group of microscopic animals with plump bodies and eight legs ending in delicate claws. They're famously resilient, able to survive exposure to space, freezing temperatures and boiling for an hour, though they can be killed by longer exposure to hot water. Scientists have long been interested in how tardigrades do this. Many animals that can survive long periods of desiccation, like aquatic crustaceans known as brine shrimp, use sugars called trehalose to essentially freeze their cells in a glass-like state that protects their inner workings until the animals are exposed to water again. But tardigrades don't have much trehalose. What they do have are numerous proteins not found in other animals. These are hard to understand, because in a non-tun tardigrade they appear disorganised and disordered, though a 2017 genetic study found that some of these disordered proteins seem to promote a glassy state in dried-out tardigrades, much like trehalose does in other animals.

The research focused on a group known as cytoplasmic-abundant heat-soluble (CAHS) proteins. In tardigrades, these proteins float around the cytoplasm, or liquid filling the cells. Kunieda and his colleagues discovered these proteins a decade ago, and other research groups found that the proteins were involved in the survival of tardigrades during desiccation. But no one knew how. Kunieda and his team ended up circling back to CAHS proteins while looking for tardigrade proteins that changed form upon stress. They identified more than 300, and CAHS proteins were among them.

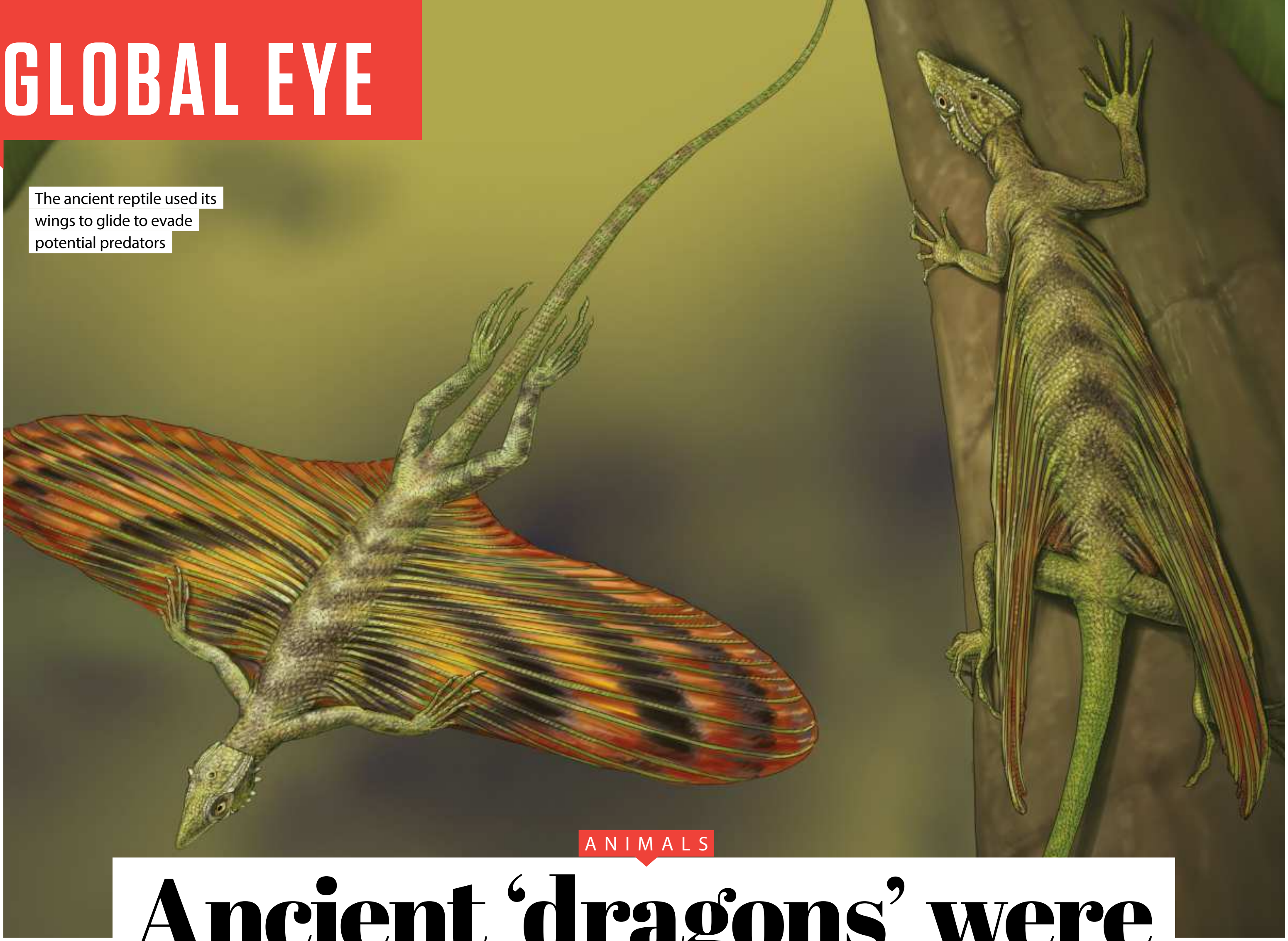
To learn what CAHS proteins do to protect tardigrades under duress, the researchers dehydrated CAHS-carrying cells and analysed how the proteins changed. They found that when the cells were threatened with desiccation, these proteins condensed, forming a network of filaments. These filaments shored up the cell, transforming the cytoplasm into a gel-like state and preventing the cell from collapsing as water leached out. This condensation happened in minutes, and reversed just as quickly. Within six minutes of rehydration, a cell could be up and running normally again.

In their experiments, the researchers found that CAHS could make insect cells more resilient to desiccation, but those CAHS-enhanced cells still weren't as tough as tardigrade cells. That means CAHS wasn't working alone. Fortunately, there are plenty of tardigrade proteins to study – researchers identified more than 300 that react to stress.



Tardigrades can enter cryptobiosis to withstand temperature and moisture extremes

© Ryan Clairmont, NASA, ESA, HEIC, and The Hubble Heritage Team (STScI/AURA) / Getty / Alamy



The ancient reptile used its wings to glide to evade potential predators

ANIMALS

Ancient ‘dragons’ were Earth’s first gliding reptiles

WORDS **JENNIFER NALEWICKI**

While most ancient reptiles crawled, scuttled and hopped through their prehistoric habitats, one creature opted for an airborne technique: gliding. Tiny, dragon-like *Coelurosauravus elivensis* used a pair of patagials, thin membranes that extended from its torso to its front limbs, forming a winglike structure to travel from treetop to treetop. Researchers from the National Museum of Natural History in Paris are calling the critter “the world’s first gliding reptile”. Ever since the first fossils of the animal were discovered in 1907, palaeontologists grappled with how this species – which measures roughly ten centimetres in length – evolved to glide during the late Permian period, between 260 and 252 million years ago. But now researchers think they’ve solved the mystery.

“The resulting picture is that of a forest where the trees are sufficiently closely spaced that the treetops overlap,” said Valentin Buffa, a palaeontologist with the National Museum of Natural History. “This allowed animals to move around in the trees without needing to come down to the ground where the predators are, and over time this could have driven the evolution of gliding adaptations. *C. elivensis* was likely a great climber, able to move up and down tree trunks easily, and had the ability to jump and glide between branches and trees, saving it from having to come down to the ground even more.”

Researchers deduced how the gliding reptile moved by reconstructing its skeleton, using fossils from three individuals. The most complete of these, a skeleton found in Madagascar, was sufficient to reconstruct nearly all of the skeleton – about 90 per cent – for this species. Prior to this reconstruction, researchers were uncertain about the exact placement of the patagials on the animal’s body. In the new study, the authors proposed that the winglike structures were most likely located low on the trunk, extending from the gastralia – dermal bones located between the sternum and pelvis – or from the trunk’s musculature.

Researchers also compared the proposed location of *C. elivensis*’ patagials to those of *Draco*, a genus of modern-day gliding lizards. Often called ‘flying dragons’, *Draco* lizards live predominantly in the rainforests of Southeast Asia. The scientists reported that *C. elivensis*’ “gliding apparatus sat lower on the abdomen than it does on modern gliding lizards,” and that *Draco*’s patagials are supported by its long and flexible ribs. Modern *Draco* lizards are not closely related to the ancient *C. elivensis*, but the two likely evolved to have similar body types through convergent evolution, or when animals in similar environments independently develop similar traits.

“Based on known behaviour of *Draco*, we suggest *C. elivensis* was able to flex its wrists backwards and interlock its finger claws between the scales on top of its wing,” Buffa explained. “This likely allowed it to extend the wing and keep it open even at higher speeds, as well as provide some degree of [pliability] by slightly moving the arms.” What’s more, “the length and curvature of the patagials allow for the reconstruction of a very wide wing in *C. elivensis*. That would have generated much lift while airborne, which likely allowed it to glide a significant distance.”

Did you know?

Modern gliding lizards have been recorded gliding up to 60 metres

PLANET EARTH

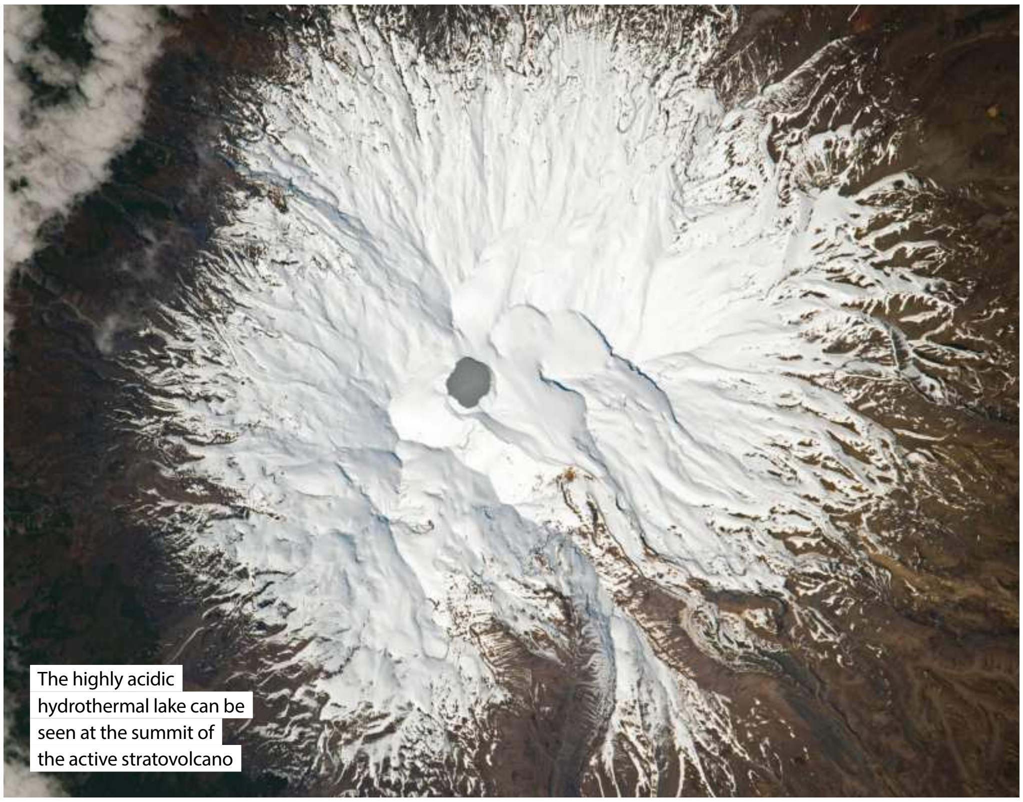
Acid lake atop 'Mount Doom' in striking new image from space

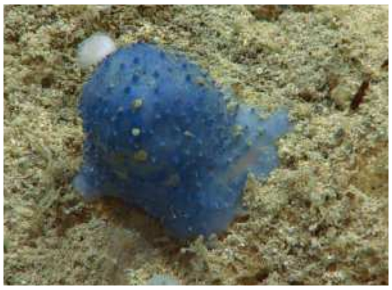
WORDS **HARRY BAKER**

An astronaut aboard the International Space Station (ISS) has snapped a stunning image of a snow-circled hydrothermal lake atop the real-life Mount Doom in New Zealand. Mount Ruapehu, New Zealand's largest active volcano and the setting used to film Mount Doom in *The Lord of the Rings* movies, sits at the heart of Tongariro National Park, a UNESCO World Heritage Site located at the centre of New Zealand's North Island. Other locations in the park were also used to portray the evil realm of Mordor in Peter Jackson's cinematic adaptation of J. R. R. Tolkien's fantasy epic series. An unidentified astronaut, part of the Expedition 65 crew on board the ISS, snapped the stunning new photo on 23 September 2021 as the station passed over the volcano.

The hydrothermal lake at the summit of Mount Ruapehu, known as Crater Lake, or Te Wai ā-moe in Māori, sits between the mountain's three main peaks, the tallest of which reaches 2,797 metres above sea level. A magma chamber deep within the volcano heats the lake, and as a result the temperature of the lake fluctuates between 15 and 45 degrees Celsius. The lake is also highly acidic – with a pH of less than one – due to large amounts of volcanic gases that dissolve in the water. Crater Lake is important to geologists who monitor the volcano's threat level. The hydrothermal lake is the only accessible part of the volcanic system that researchers can study, and rapid temperature fluctuations in the water can reflect changes in the activity below the volcano's snowy peak.

In June, the alert level for Mount Ruapehu was increased from 'minor volcanic unrest' to 'moderate to heightened volcanic unrest following a mini-swarm of earthquakes underneath the volcano. During this time, the temperature of the water in Crater Lake sharply increased to a peak temperature of 40 degrees Celsius. But the alert level was downgraded in July after the water temperature dropped to 24 degrees Celsius. Based on the temperature changes in the lake, experts believe the spike in activity was the result of a brief magma intrusion in the chamber below the volcano.


The highly acidic hydrothermal lake can be seen at the summit of the active stratovolcano


A close up of one of the mysterious 'blue goo' creatures discovered by researchers near Saint Croix in the Caribbean

ANIMALS

MYSTERIOUS 'BLUE GOO' ON THE OCEAN'S BOTTOM STUMPS SCIENTISTS

WORDS **HARRY BAKER**

Unidentified deep-sea 'blue goo' creatures recently left scientists scratching their heads after they spotted the mysterious blobs hanging out on the seafloor in the Caribbean. During a live stream of an expedition, team members discussed what the gloopy globules could be, but none of the researchers could come up with a definitive answer. The mysterious blobs were discovered sitting motionless on the seafloor between 407 and 611 metres beneath the water's surface.

During the stream, researchers spotted and zoomed in on one of the unusual blue creatures and began discussing what it could be. Some observers noted that it was likely to either be a soft coral or sponge, and potentially even a tunicate – gelatinous marine invertebrates that are sometimes referred to as sea squirts. The team suggested a number of potential nicknames, including 'bumpy blue thing', 'blue biomat' and 'blue goo'. The expedition members could only agree on what the mysterious creature was not. The team will now begin the lengthy process of trying to identify the puzzling blue goo. If experts are unable to identify the species then "the mystery will remain until a sample can be collected," they said.

© NOAA Ocean Exploration, Voyage to the Ridge 2022 / Charlène Letenneur / NASA Earth Observatory

WISH LIST

The latest tech for **WINTER**

EMBER CUP

WWW.UK.EMBER.COM £99.95 / $99.95

Arguably one of the most high-tech coffee cups in the world, the Ember Cup is a gadget that will keep your beverage warm throughout winter. Using the cup's companion app, coffee lovers can set their preferred drinking temperature, which the Ember Cup will maintain for up to 1.5 hours, or all day when connected to the cup's charging coaster. When your beverage has reached the desired temperature and is ready to drink, you'll get a notification straight to your phone. The Ember Cup is suited for those that enjoy espresso-based drinks, such as cappuccinos and flat whites. Using the cup's built-in and wirelessly charged battery, the Ember Cup can maintain around 177 millimetres of coffee between 50 and 65 degrees Celsius.

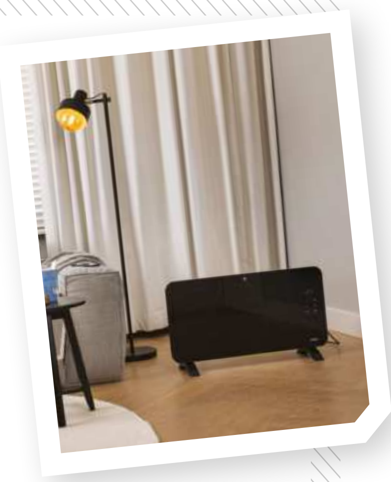
OCOOPA
RECHARGEABLE
HAND
WARMER
Ocoopa

OCOOPA H01 FASHION

WWW.OCOOPA.COM £33 / $34.99

If you're out and about and you find yourself rubbing your hands together for warmth, then the Ocoopa rechargeable hand warmer could give you quick relief. This compact device is ergonomically designed to fit in the palm of your hand and gently releases constant warmth of up to 55 degrees Celsius from both sides. The Ocoopa comes with a USB-chargeable battery that can provide warmth in three heating settings for up to 15 hours. It also only takes around five seconds for the device to heat up. Due to its compact size and light weight of 98 grams, the Ocoopa is a simple way to get warm on the go, without the need to waste time on disposable heating pads. Finally, it doubles as a power bank to give your other devices a quick boost of energy.

Panel Heater
25°C
25°



PRINCESS SMART GLASS PANEL HEATER 1,500W

WWW.PRINCESSHOME.EU £99 (APPROX. $109.60)

An upgrade to the humble space heater, the Smart Glass Panel by Princess is a high-tech way to heat your home. This smart panel uses 1,500 watts of power to raise the temperature of a room up to 35 degrees Celsius. As a space heater, its portability means it can follow you around your home without the need to crank up the central heating to heat the entire house. There is also a function to mount the smart panel onto the wall should you want a more permanent heating solution. There are several safety features embedded into the panel, such as an automatic shut-off feature in the event of overheating and a lock on the panel's manual functions to make it child-safe. Using the heater's companion app, users can customise room temperatures and schedule patterns of heating remotely, ensuring you never have to end the day in a freezing bedroom again.

YOURS & MINE DUAL-CONTROL ELECTRIC BLANKET

WWW.SILENTNIGHT.CO.UK

£45 (APPROX. $50.20)

Feeling the chill of a winter night can begin at different times for different people. The Yours & Mine dual-control electric blanket can help satisfy the temperature preferences of you and your partner at the touch of a button. Divided into two halves, the dual-control functionality of this electric blanket allows couples to choose from three different temperature settings without affecting the other side. It comes in two sizes that can fit a double or king-size bed and is machine washable once you've disconnected the cables. The manufacturer also says that it costs a single penny per night to run and comes with overheat protection.

Silentnight
yours&mine
dual control
electric blanket

THE CHOCOLATIER ELECTRIC HOT CHOCOLATE MAKER

WWW.SALTER.COM £57.99 (APPROX. $64.70)

There isn't a better time to indulge in a hot chocolate than during winter. This electric chocolatier by Salter lets you make chocolatey beverages like the professionals. Simply add milk or dairy alternatives into the hot chocolate maker – which has a capacity of 240 millilitres – along with your favourite chocolate flakes to make velvety hot chocolate in only five minutes. As well as making smooth chocolate, it can froth milk into light or firm foam for coffees. There is also the option for cold frothing to produce foam for iced frappes. Although the device is limited in what it can produce, the flavour possibilities are endless. From salted caramel, hazelnut and gingerbread hot chocolates to matcha and vanilla-topped lattes, this device lets your imagination run wild.

C250I PROJECTOR

WWW.ACER.COM £329.99 (APPROX. $368.10)

For those cold winter nights when you want to cuddle up on the sofa and enjoy a movie with a hot chocolate, the C250i projector by Acer is a great way to enjoy your favourite films at home. Portable and compact, the C250i doesn't need a stand to project an image, giving the user a 360-degree rotational projection. Once you've decided where to view the latest series or box office hit, the C250i can project it as a 2.5-metre image in full HD quality. The integrated battery allows you to watch anything wherever you are for up to five hours before it needs recharging. There's also no need to physically connect the projector to your streaming device thanks to its Bluetooth compatibility.

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DISCOVERING KING TUT'S TOMB
YOU SWALLOW 8 A YEAR WHILE YOU SLEEP
THEY LAY EGGS UNDER YOUR SKIN
20 SPIDER MYTHS BUSTED
DADDY LONG LEGS ARE HIGHLY VENOMOUS
SPIDER SILK IS ANTIBIOTIC
SECRETS OF THE BOG PEOPLE
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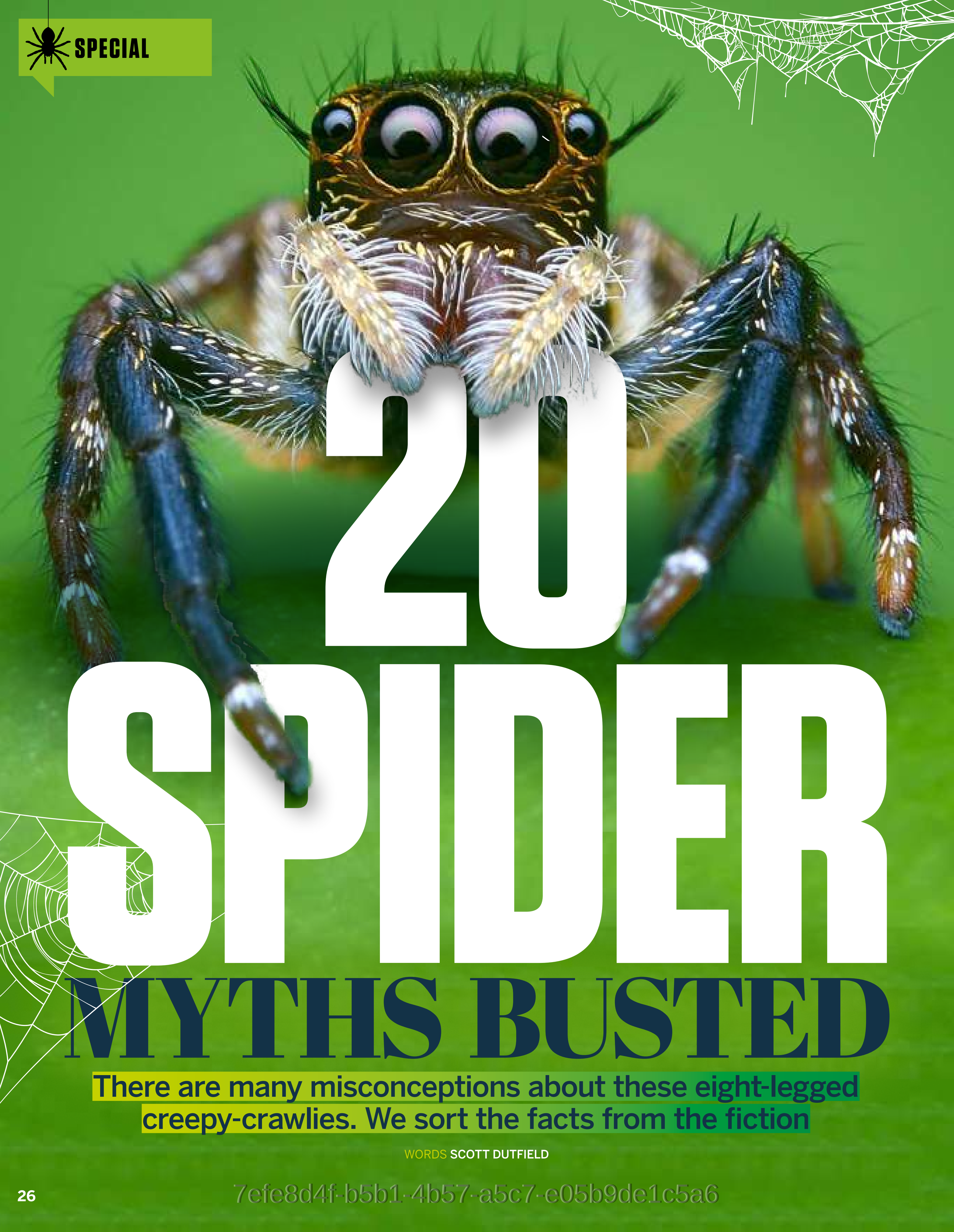

20 SPIDER MYTHS BUSTED

There are many misconceptions about these eight-legged creepy-crawlies. We sort the facts from the fiction

WORDS SCOTT DUTFIELD

DID YOU KNOW? The world's largest spider, the Goliath birdeater tarantula, has a leg span of 28 centimetres

SPIDERS ARE INSECTS MYTH

1

Although spiders and insects are evolutionary cousins, the two are very different creatures. Both spiders and insects, such as beetles and flies, have several similarities, including their comparable size, diet, habitat and lack of vertebrae. However, the two belong to different animal classes: Insecta (insects) and Arachnida (spiders). The biggest difference – and one of the distinguishing features separating them – is the number of legs each possesses. Spiders famously sport four pairs of legs, whereas insects only have three pairs. The body of a spider is also split into two segments – the abdomen and the cephalothorax, which is a combination of a head and thorax – whereas insects have three fully segmented body parts – the abdomen, thorax and head. Finally, there is no known species of spider that has developed wings, whereas almost all insects either have winged members of their species, such as ants, or metamorphose wings later on in life, like caterpillars.

Although they look related, spiders and insects are very different things

DADDY LONG-LEGS ARE HIGHLY VENOMOUS, BUT THEIR FANGS CAN'T PUNCTURE OUR SKIN MYTH

Did you know?

Some spiders ingest their webs to recycle the material

2

One of the first challenges of debunking this myth is to define what a 'daddy long-legs' is. For some it's the spider-like arachnids called harvestmen (Opiliones), for some it's cellar spiders (Pholcidae) and for others it's the crane fly. Although harvestmen look like long-legged spiders, they're not a member of the spider family. What's true about this myth is that harvestmen and crane flies don't have fangs – or in the crane fly's case any mouthparts at all. What the harvestman does have, however, is a body packed with poison, rather than injectable venom. The smell of the internal poison is intended to ward off parasites and predators. While the poison might kill any insects or predators that gobble up the harvestman, it's most certainly not a threat to human health. Crane flies, on the other hand, bear no venom, nor are they filled with protective poison. Cellar spiders have small fangs and are venomous, but they very rarely bite humans. In any case, their venom is practically harmless to us.

Harvestmen are cousins to spiders and other arachnids

SPIDERS COME INSIDE DURING WINTER

MYTH

3

Fear not, the world's spiders do not intend to invade your home during the cold months. As cold-blooded animals, spiders don't depend on external warmth to stay alive. During autumn and winter, spiders will spend their time hibernating under rocks and beneath bark, often guarding their insulated egg sacs. In the same way that house spiders have adapted to live indoors, garden-variety spiders are equally suited to winter's drop in temperature.

DEADLY SPIDERS LIVE UNDER THE TOILET SEAT

MYTH

4

Over the years, several versions of this story have emerged online, in which someone unknowingly lifts the toilet lid to find a jumping spider ready to pounce. Although there have been rare instances of spiders having mistakenly sought refuge under the seat of a toilet, more commonly in outhouses, the type of spider is rarely deadly. One of the few confirmed cases occurred in 2016, when it was reported that a young man in Australia was bitten on the genitals by a venomous redback spider after using a portable toilet, but was quickly given anti-venom.

© Getty

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ONLY HALF THE WORLD'S SPIDERS HAVE BEEN DISCOVERED

FACT

5 Since the first spider species was described in 1757, there have been 50,000 species of spiders discovered on the planet. The 50,000th spider species was described in April 2022, called Guriurius minuano and belonging to a family of jumping spiders found among the trees of South America. However, this latest discovery is by no means the last. Arachnologists at the World Spider Catalog predict that we are only halfway through finding all the spider species on Earth and that another 50,000 different species are yet to be discovered.

Guriurius minuano belongs to the jumping spider family Salticidae

4 FACTS ABOUT EIGHT-LEGGED CREATURES

1 MITES
Mites are microscopic arachnids, around 0.1 millimetres in length, that feed on both living and dead tissue. It's estimated that there are at least 45,000 different mite species that can survive in a wide range of environments, including seas, forests and inside households.

2 TICKS
These tiny blood-sucking arachnids use their eight legs to run around dense vegetation in pursuit of a red-blooded meal. As parasites, ticks secrete a cement-like glue to stick to the skin, cut the surface and use a feeding tube to guzzle blood.

3 SCORPIONS
There are around 2,000 different species of scorpions on Earth, but only around 40 of these arachnids possess a venom potent enough to kill a human. Scorpions can be found on every continent on Earth except Antarctica.

4 TARDIGRADES
Also known as water bears, tardigrades are not related to spiders but share their eight-legged quality. There are around 1,300 different species of these hardy creatures, which can survive in the world's most extreme environments, such as at temperatures close to absolute zero, or -273.15 degrees Celsius.

Did you know?

The smallest spider has a body length of 0.37 millimetres

YOU SWALLOW EIGHT SPIDERS A YEAR

MYTH

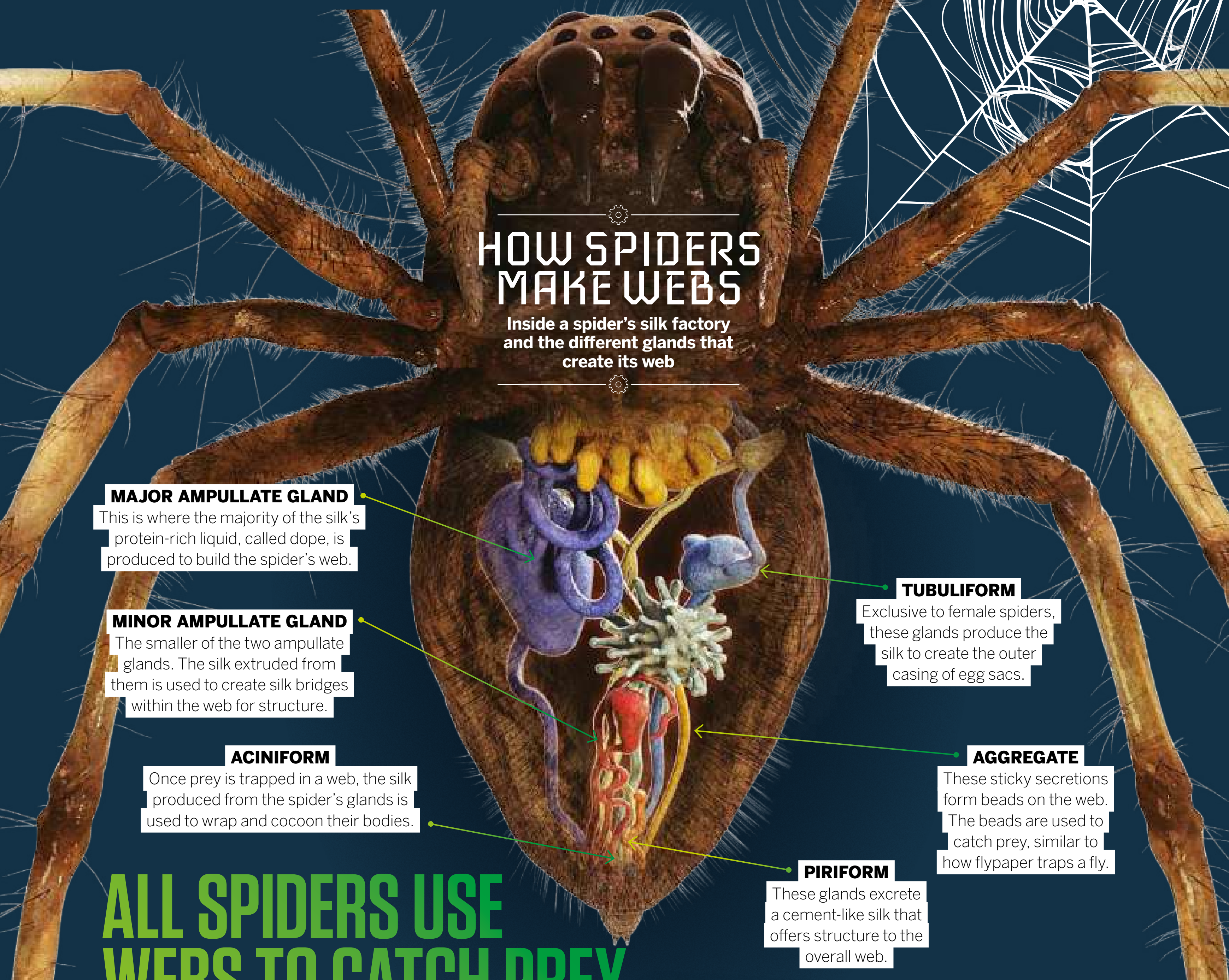
6 It's believed that this myth started in 1993 when a journalist called Lisa Holst wrote an article about myths and folklore that quoted this entirely false statistic. Despite Holst clearly stating it to be untrue, it's since become a common misconception. It's not that you don't swallow eight spiders, but rather you don't swallow any spiders while you sleep. There have been no formal studies that state spiders seek out our unconscious mouths or indeed would benefit from climbing into them. There's also the chance that if a person is sleeping with their mouth open then they are also snoring. The thunderous sound of a snore is likely to scare off any nearby spiders. In the highly unlikely event that a spider is still drawn to the cavernous allure of a person's mouth and ignores the snoring siren, any person would likely be woken by the sensation of spider's feet crawling over their face and into their mouth.

You can sleep peacefully now

DID YOU KNOW? Spiders rely not only on muscle contraction, but blood pressure to move their legs

HOW SPIDERS MAKE WEBS

Inside a spider's silk factory and the different glands that create its web



MAJOR AMPULLATE GLAND
This is where the majority of the silk's protein-rich liquid, called dope, is produced to build the spider's web.

MINOR AMPULLATE GLAND
The smaller of the two ampullate glands. The silk extruded from them is used to create silk bridges within the web for structure.

ACINIFORM
Once prey is trapped in a web, the silk produced from the spider's glands is used to wrap and cocoon their bodies.

TUBULIFORM
Exclusive to female spiders, these glands produce the silk to create the outer casing of egg sacs.

AGGREGATE
These sticky secretions form beads on the web. The beads are used to catch prey, similar to how flypaper traps a fly.

PIRIFORM
These glands excrete a cement-like silk that offers structure to the overall web.

ALL SPIDERS USE WEBS TO CATCH PREY

MYTH

7 Silk webs are synonymous with spiders. Around half of Earth's spiders spin webs to catch their prey in a sticky trap. Spider webs can be divided into seven categories: sheet, tangle, funnel, lace, radio, purse and, most commonly, the orb web. However, the remaining spider species employ other methods to snag a meal, the most common of which is to simply ambush their prey. Spiders such as the flower crab spider or water spider sit and wait for their prey to pass by and pounce once they are in range. Some spiders, like the bird-dropping spider (*Phrynarachne decipiens*), don't wait for prey to pass, but instead have evolved ingenious ways to bring their prey to them. As the name suggests, the bird-dropping spider mimics the appearance of bird waste and even emits a scent similar to faeces to attract flies and butterflies looking for a dung meal.

A bird-dropping spider awaiting the next prey insect to sniff out its alluring dung scent

© alamy / Getty / Illustration by Nicholas Forder

SPIDERS HAVE BLUE BLOOD

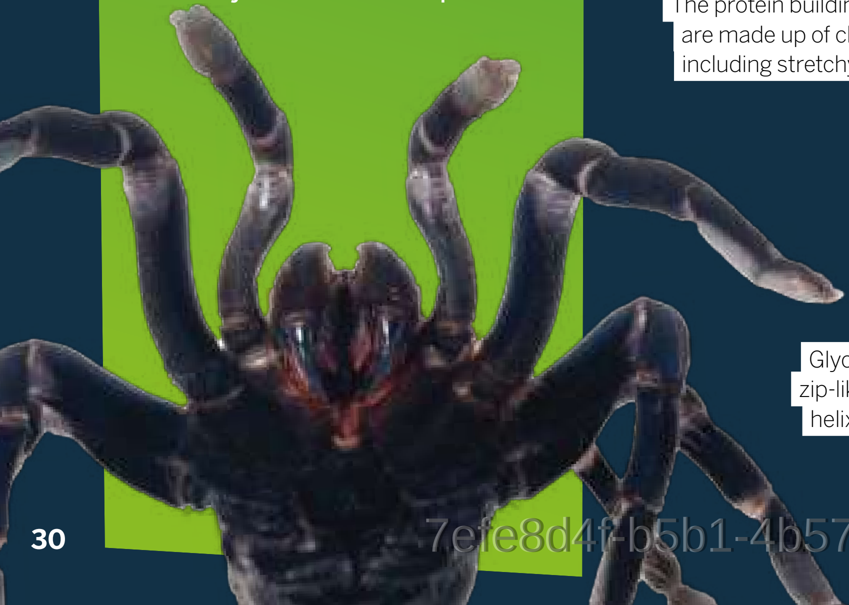
FACT

8 They might not be royals, but spiders have blue blood filling their bodies. Unlike mammals, which have rich red haemoglobin in their blood to transport oxygen around the body, spiders use a similar molecule called hemocyanin. Whereas haemoglobin uses iron atoms to bind with oxygen, hemocyanin uses copper to transport oxygen around the spider's body. Hemocyanin also absorbs all wavelengths of light except for those at the shortest end of the spectrum, reflecting it to appear blue. Spiders share this trait with snails and octopuses.

SPIDERS ARE AGGRESSIVE TO HUMANS

MYTH

9 Unlike what horror movies might have you believe, spiders are not out to get you. Unless you're one of the spider's prey species, such as insects, frogs, small rodents and even some snakes, spiders have little interest in humans. Only around one per cent of the spiders on Earth are capable of causing serious illness to humans. Spiders rarely attack humans unless they are threatened or provoked.



Spiders spin several strands of silk from tiny ducts called spigots

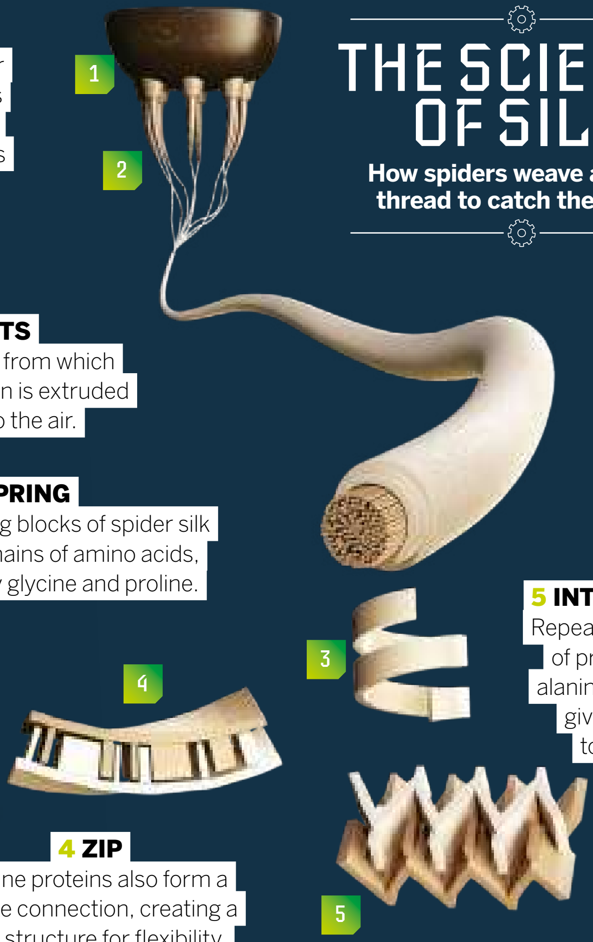
SPIDER SILK IS STRONGER THAN STEEL

FACT

10 Although spider silk needs to bear the weight of its eight-legged creator and catch of the day, it's surprisingly strong. The silk's structure consists of proteins made up of hydrophobic (water-repelling) molecules that rapidly form when the liquid silk, called dope, is extruded from the spider's glands. To put the silk's strength to the test, scientists recreated the chemical structure of silk and compared the fibres to the strength of steel, discovering that silk is tougher than steel and the energy needed to break natural spider silk is higher than steel at comparable densities.

THE SCIENCE OF SILK

How spiders weave a tough thread to catch their prey



1 SPINNERET
The site where spider silk is made. As silk is released into the air, the protein molecules are stretched and linked together to form the thread.

2 SPIGOTS
Microscopic ducts from which the liquid silk solution is extruded and exposed to the air.

3 SPRING
The protein building blocks of spider silk are made up of chains of amino acids, including stretchy glycine and proline.

4 ZIP
Glycine proteins also form a zip-like connection, creating a helix structure for flexibility.

5 INTERLOCKING
Repeated sequences of proteins called alanines interlock to give the silk its toughness.

DID YOU KNOW? Each spider leg has six joints, giving them a total of 48 knees

It's true that spiders are likely close by, but how close on average is unknown

YOU'RE NEVER MORE THAN A METRE AWAY FROM A SPIDER MYTH

11 There are about 3 million spiders for every person on the planet, so it stands to reason that no matter where you are a spider might not be far behind you. However, this is completely false; its origins can be traced back to an arachnologist called Norman Platnick. An article Platnick wrote in 1995 stated: "Wherever you sit as you read these lines, a spider is probably no more than a few yards away." As time progressed, Platnick was repeatedly misquoted until the current myth of one metre emerged. The truth is that it's difficult, if not impossible, to calculate exactly where your nearest spider is, but it's safe to say that one is probably not all that far away.

CAMEL SPIDERS EAT SOLDIERS' LIMBS WHILE THEY SLEEP MYTH

12 Born from conflict in the Middle East, myths about the camel spider have transformed it into a mythical monster among the dunes. Along with running at super speeds and growing to abnormal size, one of the most prevalent myths about these arachnids relates to their venom. Horror stories about soldiers waking up with part of their limbs missing after a camel spider has delivered a numbing bite and feasted on flesh have circulated following the Iraq War. But camel spiders aren't as sinister as they've been made out to be. Although a bite from a camel spider – which is an arachnid but not technically a spider – might be painful, they don't possess any venom and don't feast on human flesh.

A camel spider in the Pana district of Madhya Pradesh, India

Did you know?
The world's oldest spider lived to be 43 years old

It's kinder to find spiders a safe place to live in your home than to toss them out of the window

YOU SHOULD SET HOUSE SPIDERS 'FREE' MYTH

13 Although it might seem like the kindest thing to do when faced with an unwanted house guest, throwing a spider outside might be doing more harm than good. The majority of spiders in our homes are more often than not Pholcidae or giant house spiders (*Eratigena atrica*), with some species such as false widows accidentally wandering inside by mistake. House spiders in particular have over time become adapted to the mild environmental conditions of our homes and therefore don't often survive outside without the help of a human-made structure for protection.

ONLY SPIDERS HAVE EIGHT LEGS MYTH

14 It's unclear why exactly spiders evolved to have eight legs. Perhaps the extra limbs assist them in living on a web or getting around in the wilderness. What scientists do know is that there are plenty of other animals that share this number of limbs. One of the characteristics of arachnids is having four pairs of legs. Within the class are tens of thousands of different non-spider species, all with eight legs.

© Alamy / Getty / Illustration by Nicholas Froder

SPIDERS IN AUSTRALIA ARE MOST DANGEROUS

MYTH

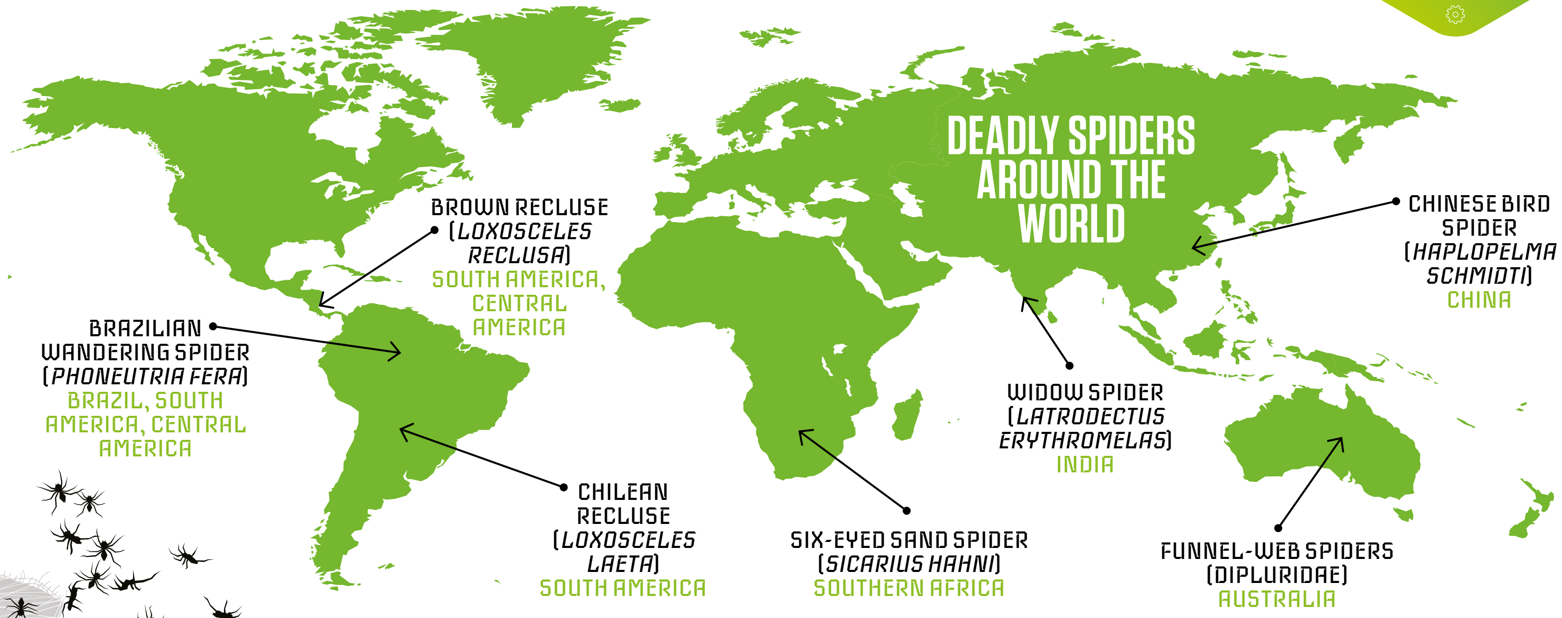
15 There are around 10,000 different species of spiders that are found in Australia, including the most deadly species on Earth, the Sydney funnel-web spider (*Atrax robustus*). Found in New South Wales, these forest dwellers have fangs strong enough to break through fingernails and a potent venom that can damage the central nervous system and cause death. However, this is just one of many deadly arachnids found all over the world.

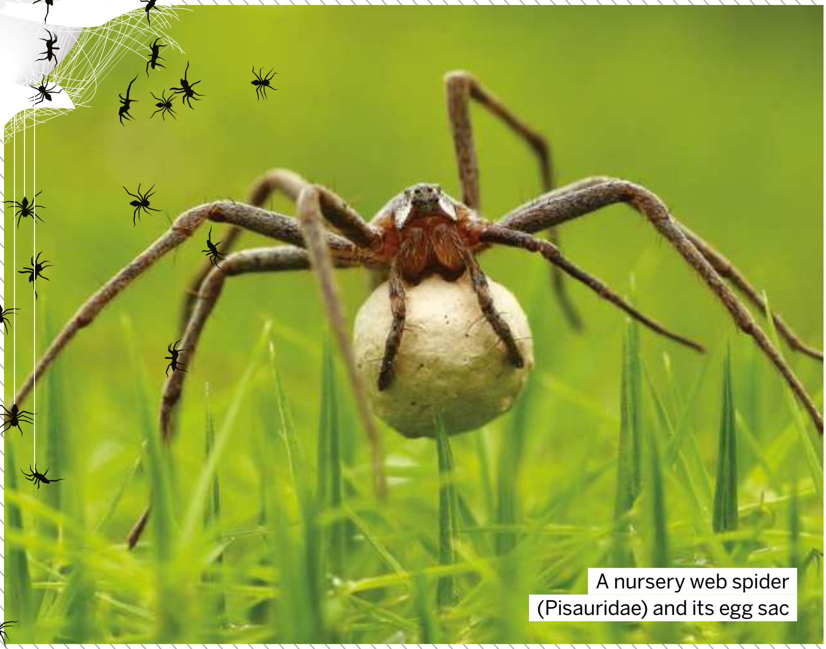
Funnel-web spiders are venomous

Did you know?

Lizards are the main predators of spiders

DEADLY SPIDERS AROUND THE WORLD


BROWN RECLUSE (*LOXOSCELES RECLUSA*)
SOUTH AMERICA, CENTRAL AMERICA
BRAZILIAN WANDERING SPIDER (*PHONEUTRIA FERA*)
BRAZIL, SOUTH AMERICA, CENTRAL AMERICA
CHILEAN RECLUSE (*LOXOSCELES LAETA*)
SOUTH AMERICA
SIX-EYED SAND SPIDER (*SICARIUS HAHNI*)
SOUTHERN AFRICA
WIDOW SPIDER (*LATRODECTUS ERYTHROMELAS*)
INDIA
FUNNEL-WEB SPIDERS (DIPLURIDAE)
AUSTRALIA
CHINESE BIRD SPIDER (*HAPLOPELMA SCHMIDTI*)
CHINA



A nursery web spider (Pisauridae) and its egg sac

SPIDERS LAY EGGS UNDER YOUR SKIN

MYTH

16 The life cycle of a spider differs between species, but they tend to begin their lives emerging from an egg that has been bundled together by their mother's silk to form a cocoon-like sac. Spider sacs, which bear hundreds if not thousands of spider offspring, come in all different shapes and sizes and can be found anywhere, such as beneath bark, under leaves, in the corner of a window or even underwater. However, somewhere where you won't find spider eggs is beneath your skin. Outside of fiction and sensationalist hearsay, spiders are anatomically unable to tear a hole in human skin and inject their unborn offspring beneath it. But there are many creatures that can, such as *Loa loa* worms and lice.

DID YOU KNOW? Between 3 and 15 per cent of the global population suffer from a fear of spiders, called arachnophobia

SPIDER SILK IS ANTIBIOTIC

MYTH

17 Spider silk has many amazing properties and abilities, but being an antibacterial agent is not one of them. Throughout history silk has been seen as a remedy for healing wounds and a defence against pathogens due to its supposed antibacterial chemical compounds. The practice of treating wounds with spider webs has been discovered in ancient Greek and Roman medicine. Several studies have investigated the medicinal properties of spider silk. While some anecdotal evidence supports some antibiotic ability, recent combative studies have challenged the methodology behind these studies and concluded the findings are inaccurate.

MYSTERY BITES LIKELY COME FROM SPIDERS

MYTH

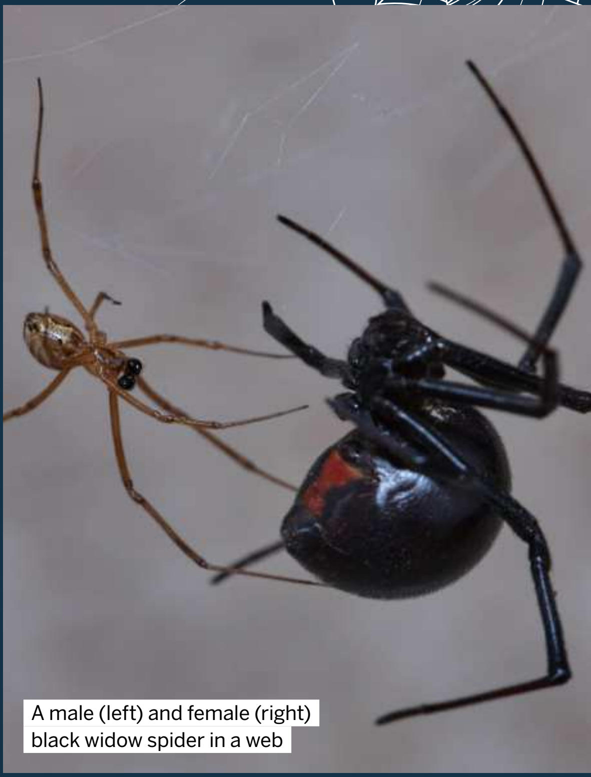
18 When a mysterious itchy red patch appears on the ankles or legs, we often turn to spider bites as a likely explanation. Considering that situations where spiders inevitably come into contact with skin are uncommon and unprovoked bites are rare, mystery bites are likely to come from other sources. The most common sources of bites are from mosquitos, blood-sucking bed bugs, ticks or mites. A bite from these bugs often leaves a red and inflamed mark on the skin. Studies have also shown that the beginnings of a methicillin-resistant *Staphylococcus aureus* (MRSA) infection can also look like swollen red spots that can be mistaken for spider bites. However, the occurrence of a spontaneous spider bite is not impossible and can often be identified by small puncture marks in the skin.

A close up of a brown recluse (Loxosceles reclusa) spider bite

BLACK WIDOWS EAT THEIR MATES

FACT

19 Among widow spiders (*Latrodectus*), mating can be a dangerous game, at least for males. Females are often left without their mate, hence the 'widow' part of their name, and this is because after mating, males are devoured by their much larger partners. They even somersault into the fangs of the female. Scientists believe that this sacrifice is to ensure that females receive as much of the male reproductive sperm as possible, internally stockpiling sperm cells in a separate organ to fertilise her eggs at a later date. But this sexual cannibalism isn't guaranteed. Studies of brown widows found that despite the reproductive benefits of being eaten, males were only cannibalised by just over half of their mates.



A male (left) and female (right) black widow spider in a web

SPIDERS DON'T USE THEIR FANGS TO EAT

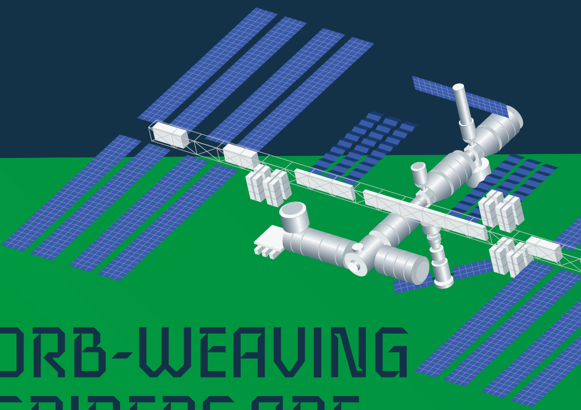
MYTH

20 As an integral part of their anatomy, fangs give many spiders the power to puncture their prey and inject a fatal dose of venom. However, fangs also play a role in the actual mastication of their food. Within the spider's venom are digestive enzymes that begin to break down and liquidise the prey's body before it enters the spider's. Once the enzymes have partly dissolved the prey into a gooey meal, the spider will use its mouthpart to slurp it up. Toothed jaws, fangs and mandible-like structures called maxilla assist in moving and breaking down tissue.

A jumping spider (Salticidae) eating its insect prey

© Alamy / Getty

SPIDERS BY NUMBERS



ORB-WEAVING SPIDERS ARE ABLE TO ADAPT TO MICROGRAVITY ABOARD THE INTERNATIONAL SPACE STATION

WOLF SPIDERS CAN ONLY SEE IN GREEN AND ULTRAVIOLET LIGHT

315 MILLION YEARS AGO

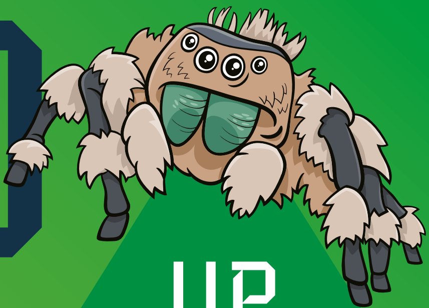
Spiders evolved from ancient arachnids during the Carboniferous period

360 DEGREES

Jumping spiders have an all-round field of vision

9,000

Some species of *Argiope* spiders lay thousands of eggs, but only around two per cent survive into adulthood



UP TO 50x

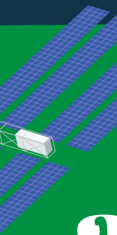
Jumping spiders can leap many times their own body length

80%

In some spider species, the central nervous system takes up the majority of space in their bodies

The *Bagheera kiplingi* spider lives on a mostly plant-based diet

DID YOU KNOW? Funnel-web spiders have two-centimetre-long fangs



Spiders always have four legs in the air when they walk

2.8 SQUARE METRES

Darwin's bark spiders (*Caerostris darwini*) create the world's largest cobwebs

15x

Black widow venom is many times more potent than a rattlesnake's

400 TO 800 MILLION TONNES

The annual global spider population's consumption of insects and invertebrates

SOME WOLF SPIDERS 'PURR' TO ATTRACT A MATE

TEN MILES PER HOUR

Camel spiders can move at a fast human running pace

SOME SPIDERS USE SILK TO CREATE SAILS TO GLIDE ON THE WIND, KNOWN AS BALLOONING

3 METRES

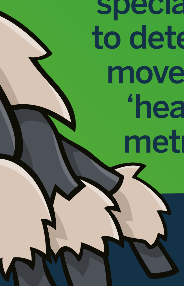
Some spiders use specialised hairs to detect particle movement and 'hear' things metres away

10,000 HAIRS PER SQUARE MILLIMETRE

Tarantulas are some of the hairiest spiders on Earth

30 TO 60 MINUTES

The average time it takes a spider to create a web



© Getty

HOW BIRDS MAKE NESTS

Explore the amazing beakwork of the world's feathered architects

WORDS **AILSA HARVEY**

DID YOU KNOW? Hummingbirds have the smallest bird nests, with some being the size of half a walnut shell

There are more than six times as many birds as humans in the world, making up at least 11,000 different species. The characteristics and habitats of these winged wonders are extremely diverse, and because birds come in a range of shapes and sizes, the nests of these animals are also very varied. Cupped nests are the most commonly encountered, which can be distinguished by their cup shape, safely housing newborn birds. Most likely spotted between the branches of trees, birds perch inside this type of nest, made mostly of intertwined twigs.

Other nests are better hidden from animal eyes as birds burrow into the ground, cliffs and tree trunks. These burrow nests provide extra warmth and safety from the environment. Instead of putting in the hard graft required to dig out these spaces, birds with cavity nests use their detective skills to find naturally existing chambers. This could be in the form of hollow trunks utilised by woodpeckers inside cactuses, which are sought out by desert owls.

A species' main priority for survival will determine which type of nest is built. The stork and bald eagle construct a platform nest to ensure 360-degree views of their surroundings. These vantage points enable the birds to spot predators sooner, and many nests remain in place to be reused across multiple breeding seasons. Some birds are unable to fly, or don't have the flying ability of high nesters. These include pheasants, turkeys and quail, which need to make their nests directly on the ground. Their homes require tall sides or grassy locations to keep eggs and young birds out of sight.

Skylarks nest on the ground, surrounded by high vegetation

Did you know?

Pigeons nest up to eight times in a year

SPIDER ASSISTANCE

Broad-billed hummingbirds wrap their nests in webs

The material that often serves as the glue in many bird nests is made by an entirely different animal. The strong silk of spiders' webs is often collected by birds and incorporated into the twig architecture to hold loose components together. Small birds, such as kinglets and hummingbirds, hold spiders' webs in their beaks and use them to wrap silk around the edge of their nests.

Because a spider's silk is made from large proteins, the material is stretchy and sticks to the nest. The flexibility of the webbing provides leeway for the nest's structure to move slightly as bird nestlings grow and bustle for space and food. In other cases, spiders themselves are used by birds. House wrens, for example, steal spider eggs and place them in their nests. Based on laboratory experiments, scientists suspect that these spiders serve as pest control for the nest. When they hatch, they feed on mites that are parasitic to the young birds.

FROM TWIGS TO DIGS

How do birds make their homes from sticks?

1

CHOOSING A LOCATION

Birds often search for a high spot in trees, where the laid eggs will be covered by foliage for protection.

2

COLLECTING STICKS

When a suitable location is decided on, birds hunt for loose sticks that they can use in their nest. Before precise placement, these sticks are dropped into the tree or general area.

3

MAKING A BASE LAYER

The collected sticks and twigs are layered to cover the area of the nest. The most common are bowl-shaped to encase the eggs and young.

4

WEAVING FIBRES

Flexible materials, such as grass, are woven in and out of the stick lattice to hold the nest more firmly in place. Birds use their pointed beaks to achieve this, and some can even tie knots.

5

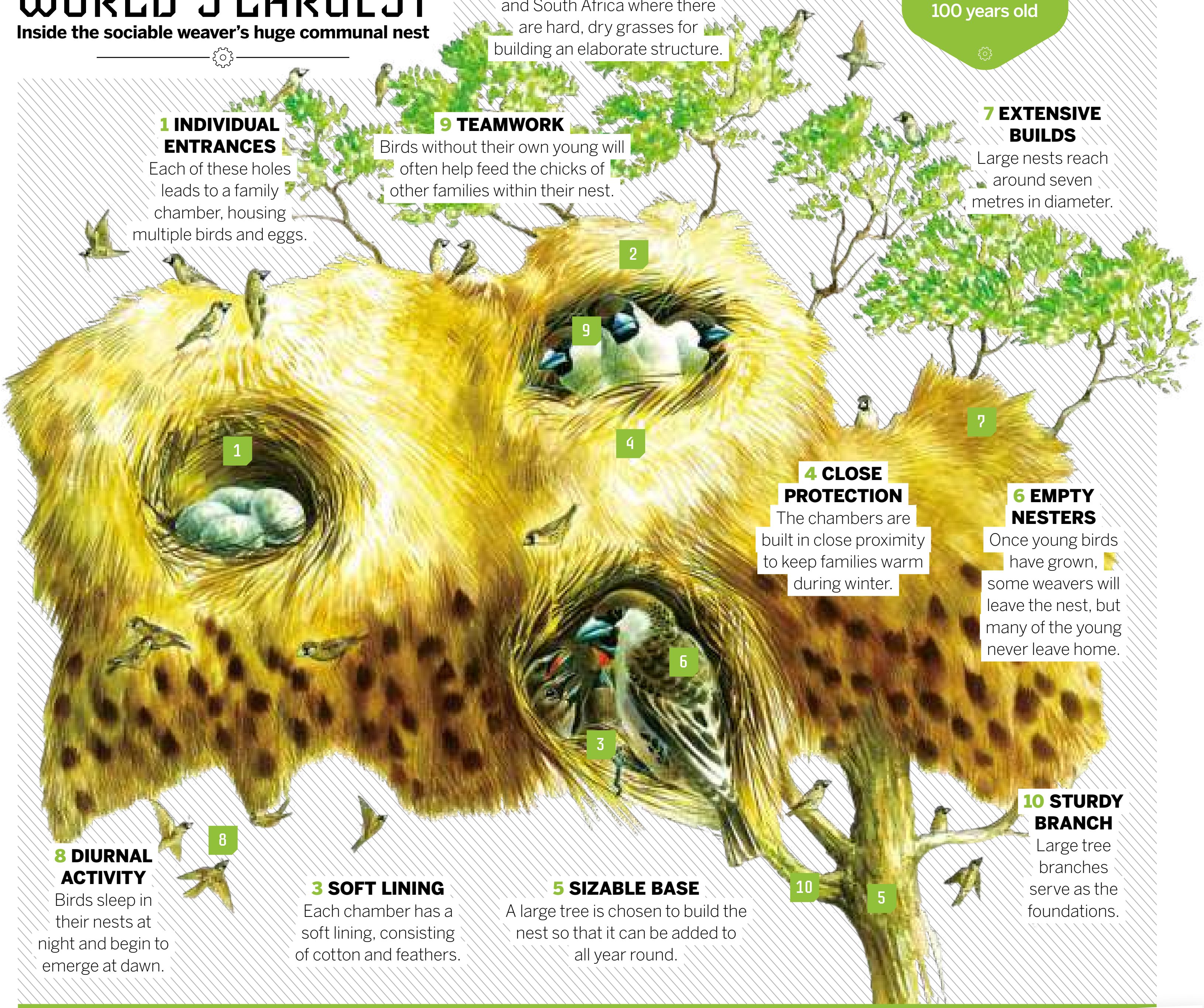
STRENGTHENING THE HOME

A sticky material is usually collected last of all, holding the structure in place. Most commonly this involves mud or silk.

© Alamy / Getty

WORLD'S LARGEST

Inside the sociable weaver's huge communal nest



2 BUILDING MATERIALS
These birds build nests in the deserts of Namibia, Botswana and South Africa where there are hard, dry grasses for building an elaborate structure.

Did you know?
Some sociable weaver nests are 100 years old

1 INDIVIDUAL ENTRANCES
Each of these holes leads to a family chamber, housing multiple birds and eggs.

9 TEAMWORK
Birds without their own young will often help feed the chicks of other families within their nest.

7 EXTENSIVE BUILDS
Large nests reach around seven metres in diameter.

4 CLOSE PROTECTION
The chambers are built in close proximity to keep families warm during winter.

6 EMPTY NESTERS
Once young birds have grown, some weavers will leave the nest, but many of the young never leave home.

8 DIURNAL ACTIVITY
Birds sleep in their nests at night and begin to emerge at dawn.

3 SOFT LINING
Each chamber has a soft lining, consisting of cotton and feathers.

5 SIZABLE BASE
A large tree is chosen to build the nest so that it can be added to all year round.

10 STURDY BRANCH
Large tree branches serve as the foundations.

SALIVA STRUCTURES

While some birds scavenge for perfectly shaped sticks to build their nests with, the edible-nest swiftlet makes its own biological building material. During the nest-making process, the birds' salivary glands enlarge. Edible-nest swiftlets are born in a nest made of 100 per cent saliva.

The saliva is released onto a flat, vertical surface like a rock or wall, and a basket-like nest is designed by the bird. The saliva hardens as it makes contact with the air to stick to the wall and existing nest. When complete, the nests are about six centimetres long and 1.5 centimetres deep – capable of holding two eggs.

The species is named the 'edible-nest swiftlet' because this bird's spit creation is a delicacy in Chinese cuisine. Most commonly these nests are added into soups. The nests have been a traditional dish for at least four centuries and are believed to have nutritional value. One particular suspected health benefit of the soup is the assistance of skin and tissue repair.

Strands of the edible-nest swiftlet's gummy saliva are visible close up

DID YOU KNOW? The saliva of an edible-nest swiftlet can sell for up to £2,400 ($2,600) per kilogram

5 NESTS TO IMPRESS

This adult elf owl lives in a cactus cavity, an abandoned woodpecker nest

1 ARTISTIC ARCHWAY

BOWERBIRD

Perhaps the most artistic nests in the bird world belong to bowerbirds. They collect the most colourful objects from their surroundings to decorate their nests and attract a mate. This can include feathers, berries and in some locations any human-made items they can get their beaks on. Their elegant nests are usually built at ground level and take the shape of a pointed upside-down archway.

2 DROPLET DESIGN

SOUTHERN MASKED WEAVER

Using wide blades of grasses and reeds, the southern masked weaver designs intricate lanterns to call home. The male birds build these teardrop-shaped nests, producing more than 20 each during breeding season. Only when a female bird is impressed by a nest does the male create a doorway for them to use. Finally, the female lines the inside with soft feathers and the nest is complete.

3 SERIAL BUILDER

EUROPEAN HOUSE WREN

The male house wren is responsible for building nests. However, the task involves making many more than the one that is eventually used. Around 12 nests will be built in varying locations, allowing a female to choose the perfect one for her. By making more than one, the bird increases his chance of finding a mate.

4 MUD HOME

OVENBIRD

The substantial clay-like constructions of the ovenbird could be mistaken for an ancient oven, but are actually the result of around six weeks of dedicated mud art. When mixed with the bird's saliva, wet mud provides flexible sculpting for the main dome and circular entrance, while incorporating plant fibres into the mix increases the nest's overall strength. There are over 200 ovenbird species building nests in various locations. These can be on forest floors or balanced upon branches.

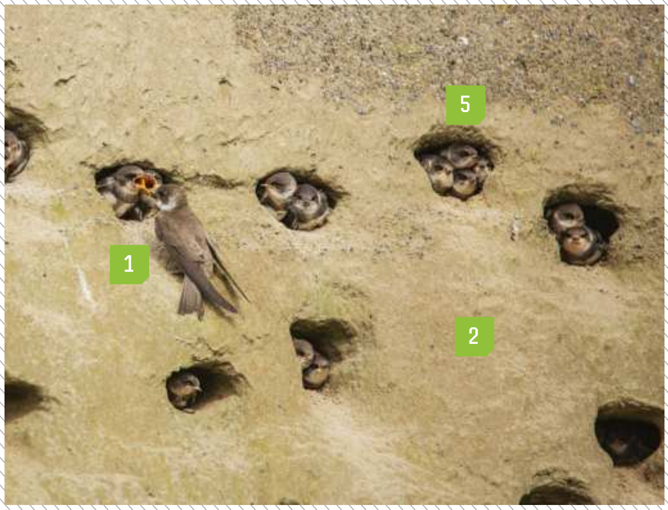
5 RUBBISH DOMINANCE

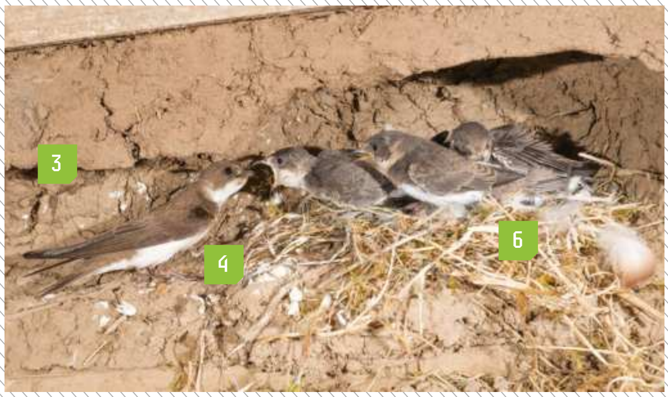
BLACK KITE

Although the majority of a black kite's nest will consist of twigs and other natural materials, these birds also seek out human rubbish to interlace or decorate their homes with. Incorporating these unusual items, such as plastic, is thought to represent social dominance to other birds. About 20 days before laying their eggs, litter is collected from the surrounding area.

THE HIDDEN HOMES OF BANK SWALLOWS

These birds burrow into vertical silt or sand banks





1 COLONIES

These birds breed in large nests that can house hundreds of pairs of swallows.

2 NEST SITES

As well as sand banks, these birds make homes in cliffs, riverbanks and wall drain pipes.

3 CREATING TUNNELS

Birds dig into the loose ground with their beaks to form 45 to 90 centimetre long tunnels, with chambers at the end of each.

4 TEAMWORK

Both male and female bank swallows take part in the nest-burrowing process.

5 TAKEOVER

If the burrows are built too wide, birds such as sparrows and starlings can take over the home.

6 INCUBATION

Four or five eggs are usually laid per chamber in May or June. They hatch after two weeks, but remain in the nest for around 20 days after hatching.

© Alamy / Getty

HOW DO DOGS SMELL?

See inside the nose of man's best friend

WORDS **SCOTT DUTFIELD**

When it comes to a strong sense of smell, there are few animals that can outperform our canine companions. In the same way that humans rely predominantly on sight as a way of perceiving their environment, dogs' dominant sense to interpret the world around them is smell, so this sense is more advanced than in other animals, including humans. On average, dogs have a sense of smell around 100,000 times more sensitive than humans thanks to millions of olfactory receptors at the front of their brains. Dogs are able to smell around one part per trillion, equal to sniffing out a teaspoon of sugar in an Olympic-sized swimming pool.

Dogs use smell as a way to communicate with other dogs, assert dominance, attract a mate and engage in play. This is evidenced when two dogs engage in sniffing each other's rear ends. A whiff of another dog's anal glands can provide them with a whole host of information, such as age, sex, health and even mood.

To ensure dogs get the most out of the many smells around them, the outer portion of a dog's nose is made wet by licking it, and each nostril is lined with mucus to capture odour particles and funnel them through the nasal passage to the olfactory receptors.

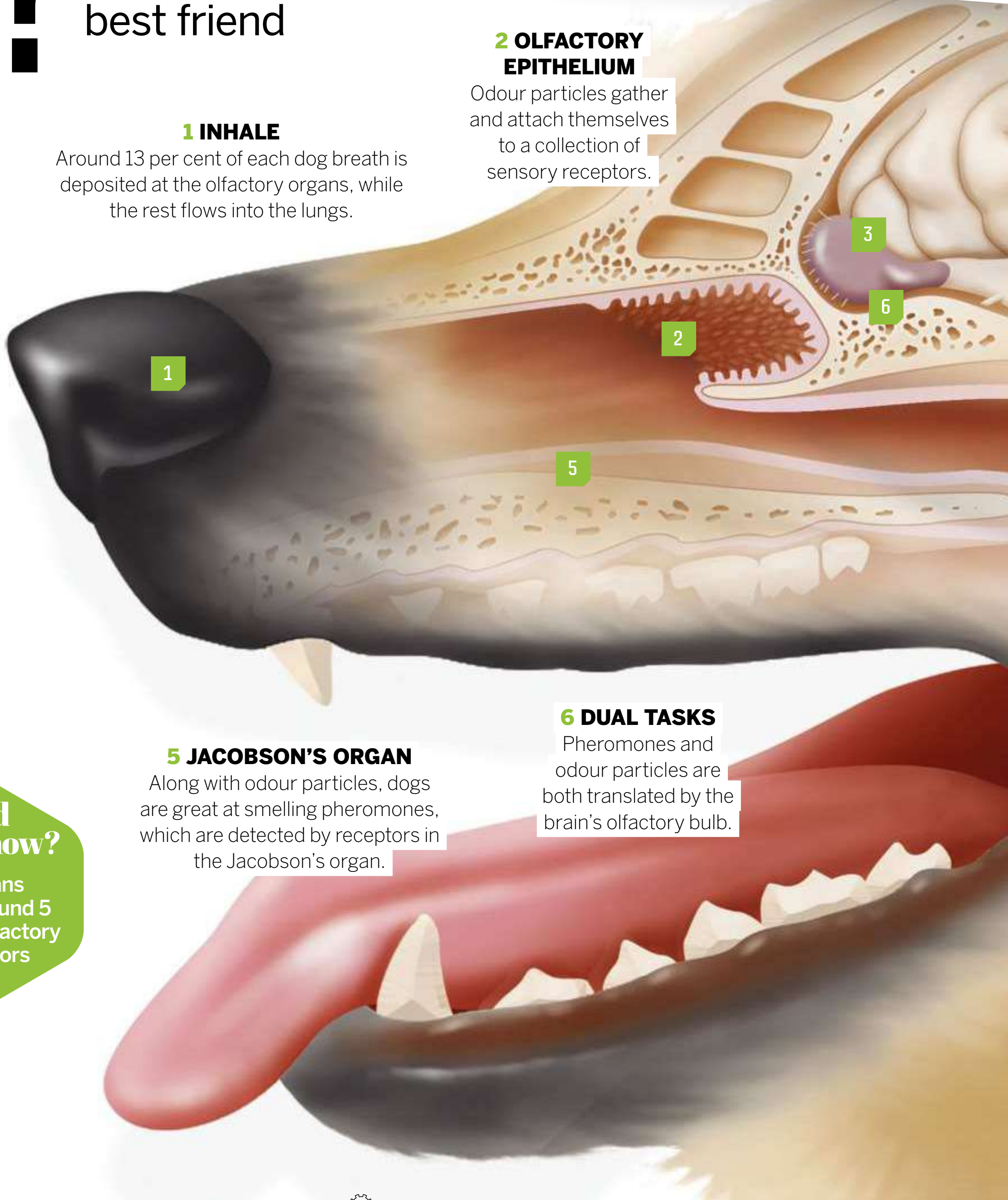
Along with a keen sense of smell, dogs have a heightened ability to detect airborne pheromones using a specialised organ in their snouts called Jacobson's organ – named after anatomist Ludwig Lewin Jacobson, who defined it in 1813. Pheromones also offer important information for dogs, such as detecting fear and attraction from other animals. Both a dog's olfactory receptors and its Jacobson's organ mean that dogs can build a picture of the world around them by sniffing.

As well as allowing dogs to navigate the world, their keen sense of smell has also proven useful for law enforcement. Through vigorous training, some dog breeds can sniff out a myriad of compounds, including illegal and dangerous substances such as drugs and explosives.

Did you know?

Humans have around 5 million olfactory receptors

Some dog breeds can smell an object or person up to 15 miles away



1 INHALE
Around 13 per cent of each dog breath is deposited at the olfactory organs, while the rest flows into the lungs.

2 OLFACTORY EPITHELIUM
Odour particles gather and attach themselves to a collection of sensory receptors.

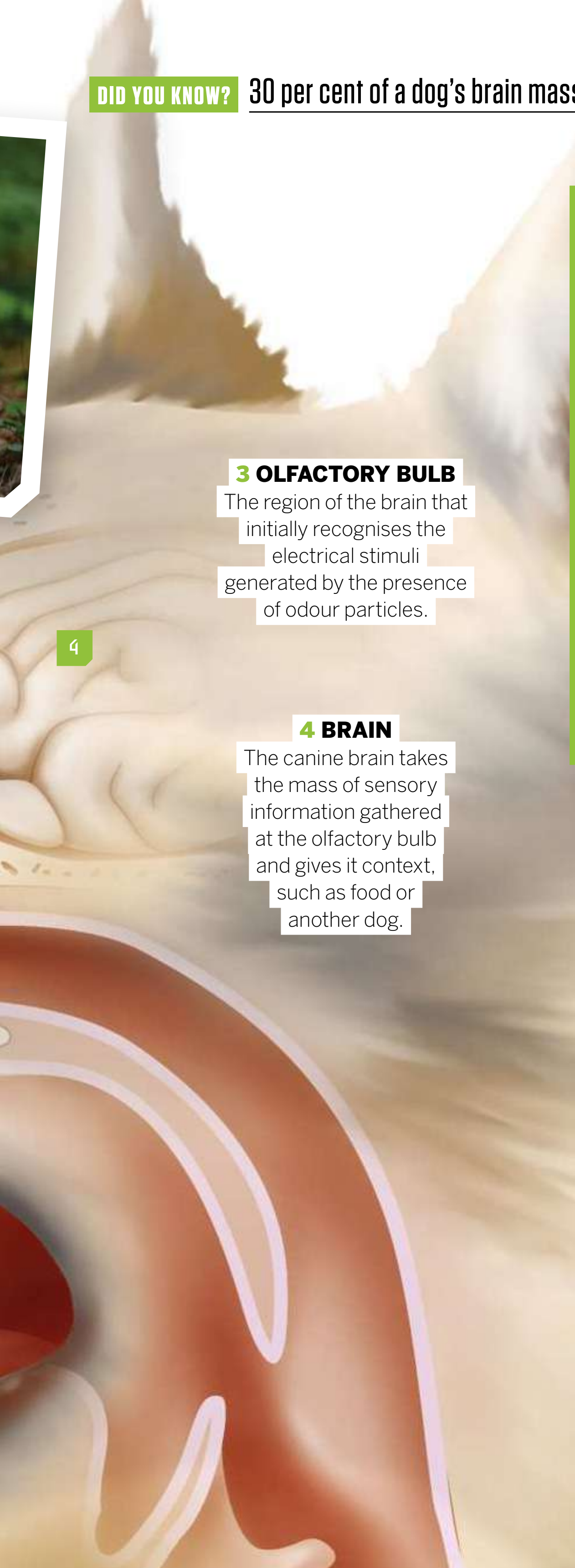
5 JACOBSON'S ORGAN
Along with odour particles, dogs are great at smelling pheromones, which are detected by receptors in the Jacobson's organ.

6 DUAL TASKS
Pheromones and odour particles are both translated by the brain's olfactory bulb.

INSIDE A DOG'S NOSE

An odorous journey through the canine olfactory system

DID YOU KNOW? 30 per cent of a dog's brain mass is dedicated to deciphering odours



3 OLFACTORY BULB
The region of the brain that initially recognises the electrical stimuli generated by the presence of odour particles.

4 BRAIN
The canine brain takes the mass of sensory information gathered at the olfactory bulb and gives it context, such as food or another dog.

DOGGY DOCTORS

Studies have shown that some dogs are able to sniff out breast and lung cancer from a patient's breath

Sniffing butts and busting criminals aren't the only ways that dogs are using their valuable noses. Following an unusual case in 1989, whereby a woman was continually pestered by her dog who seemed fixated on a mole that turned out to be malignant, researchers have studied the potential use of dogs in diagnosing diseases, including cancer. Following years of research, it's now been confirmed that some dogs are indeed able to detect the volatile compounds emitted from certain cancers, either through a person's breath, sweat, urine or blood. Along with detecting different cancers, studies have shown that dogs are also able to sniff out COVID-19 infections and even lower insulin levels in people with type 1 diabetes. Scientists are still developing a non-invasive canine method to accurately detect diseases, with their focus locked on the identity of the disease-related compounds that dogs are sniffing out.

STRONGEST SNOUTS

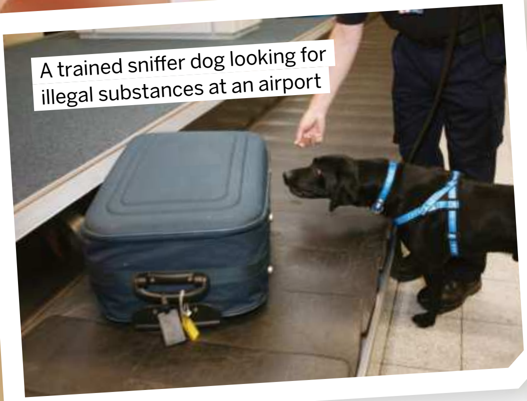
1 BLOODHOUND
With more olfactory receptors than any other breed at around 300 million, the bloodhound takes home the trophy for the most powerful nose. These dogs were historically used as hunting dogs. Now bloodhounds are mostly used by law enforcement to catch criminals.

2 BASSET HOUND
Originally bred for hunting, basset hounds have around 220 million olfactory receptors to sniff out hunted game such as rabbits. It's been suggested that their long ears allow them to sweep up scents to their nose for a better sniff.

3 BEAGLE
A study published in the *Journal of the American Osteopathic Association* found that its beagle subjects were around 97 per cent accurate when distinguishing blood samples of patients with lung cancer and healthy patients.

4 GERMAN SHEPHERD
Often used for their bomb and drug detecting abilities, these dogs are often seen alongside law enforcement and search-and-rescue teams. A German shepherd has around 225 million olfactory receptors to detect smells.

5 LABRADOR RETRIEVER
Studies have shown that labradors can detect when patients with type I diabetes are experiencing a low insulin event called hypoglycaemia. During this event, the presence of a chemical called isoprene is elevated in a patient's breath, which these dogs can detect.


A trained sniffer dog looking for illegal substances at an airport

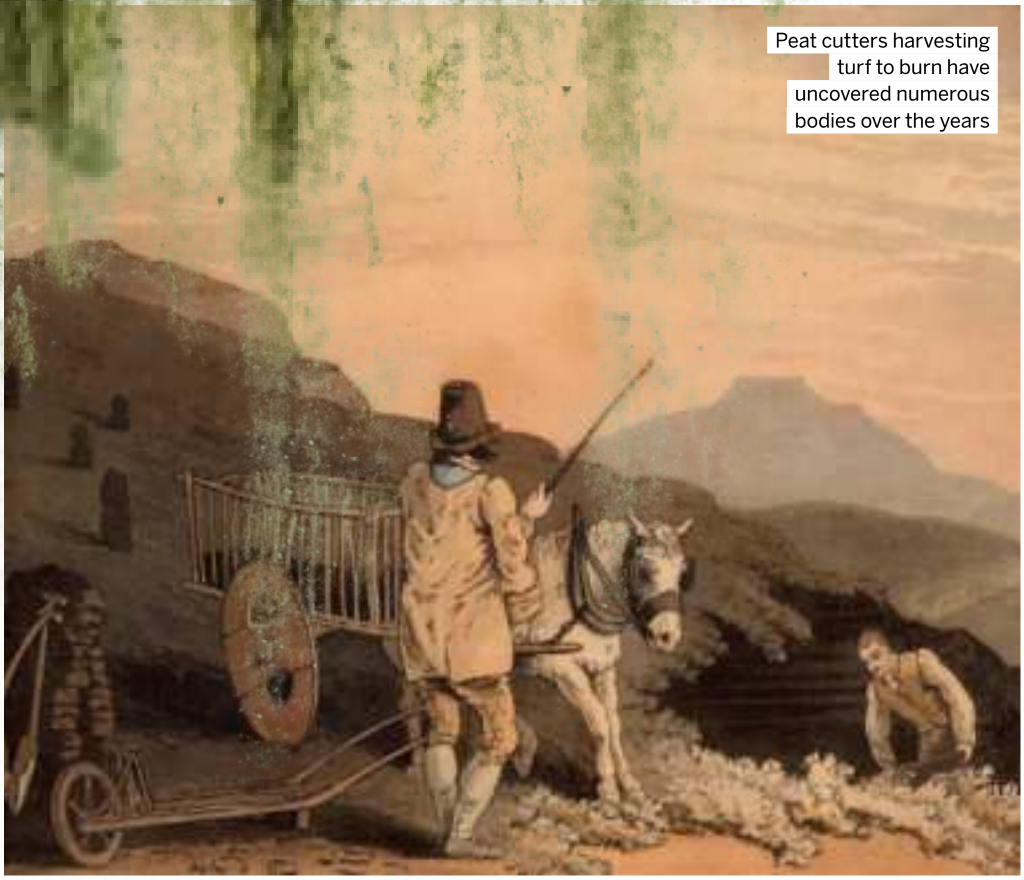
© Alamy / Getty / Science Photo Library

SECRETS OF THE BOG PEOPLE

Meet the mysterious Iron Age mummies buried in Northwest Europe's swamps

WORDS JERRY GLOVER

DID YOU KNOW? The same acids that preserve the body can dissolve the bones inside it


Peat cutters harvesting turf to burn have uncovered numerous bodies over the years

The Iron Age bog bodies of Northwest Europe are some of the best naturally preserved human remains from the ancient past. While their skin looks like tanned leather and their bodies are seemingly deflated, they are pretty similar to humans living today, which is astonishing considering many of them are at least 2,000 years old. Hundreds of these mummies have been found in the peat bogs of England, Ireland, the Netherlands, Denmark and northern Germany. While sometimes only heads and arms are uncovered, the complete cadavers that have been unearthed often bear traces of terrible violence.

Occasionally hanged or stabbed or with their bodies cut open, the shocking ways in which these people died both repels and fascinates. One of history's most profound murder mysteries, no contemporary writing can tell us for sure why they were killed or buried in violation of the normal ancient death rites. But evidence increasingly suggests they were key players in human sacrifices.

> "No contemporary writing can tell us for sure why they were killed and buried"

All of the bodies were interred in peat bogs, which form in low-lying ground where moss gathers. The small amount of oxygen prevents bacteria from breaking down the dead vegetation each year. The resulting peat increases at a rate of just one metre every 1,000 years, creating a cocktail of chemicals – or humic acid – that is able to preserve soft material and bones, tanning skin like leather.

The earliest record of a bog body find comes from Shalkholz Fen in Germany in 1640. We don't know what people thought of the mummies when they were first discovered, but it was claimed that one found at Haraldskær in Jutland was the lost remains of Queen Gunnhild in 1835. According to Icelandic sagas, she was a cunning witch who was lured to the bog and drowned by King Harald Bluetooth in the 10th century.

We now know that Haraldskær Woman is actually 1,500 years old, so she can't be Gunnhild. Her proximity to Bluetooth's royal residence at Jelling may have caused her misidentification. Cases of mistaken identity have happened elsewhere. The finding of a preserved Iron Age woman's head in Lindow Moss, England, in 1983 caused a local man to confess to the murder and disposal of his wife in the same bog – a mistake that led to his conviction.

Research into Denmark's bogs began in 1859 when Conrad Engelhardt investigated Nydam Mose in Jutland, finding iron weapons and an oak boat. They have now yielded over 500 Iron Age bodies from between 400 BCE and 400 CE. For his astonishing preservation and calm appearance, the most celebrated of these is the man who was found in Jutland's Tollund Fen in 1950. He lay on his side as if sleeping, his only attire a pointed skin cap, fastened under the chin by a hide string, and a hide belt around his waist. A rope of two twisted leather strings encircled his neck, drawn tight to cause lacerations, then it coiled across the shoulder and down his back. A few days of stubble covered his chin and upper lip, but otherwise he was clean-shaven.

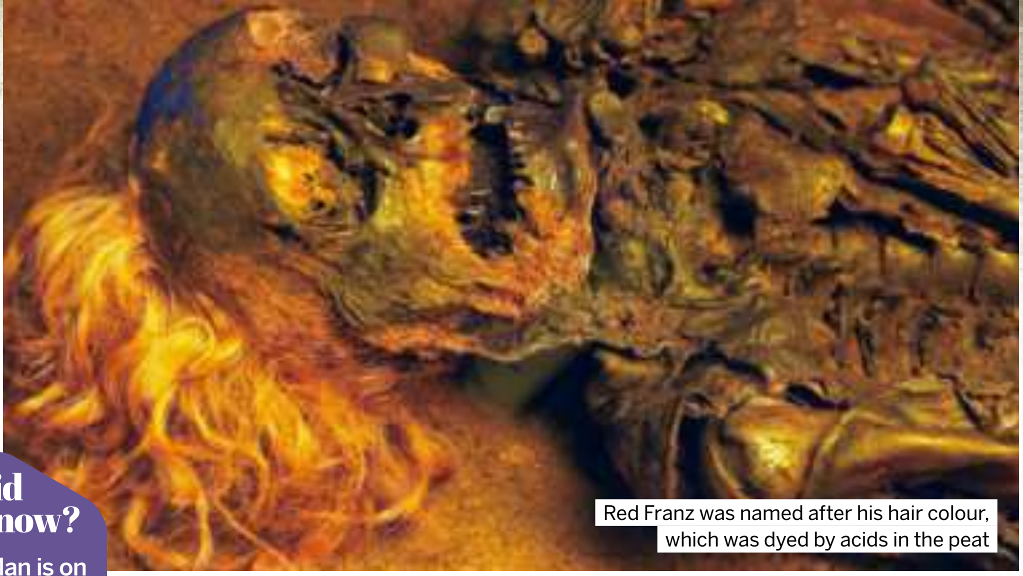
Danish police took a fingerprint from his right thumb and found that it was indistinguishable from that of a living person, a result of him being buried in the bog when the water was cold. If it had been more than four degrees Celsius, the soft body parts would have begun to decompose before the humic acid could entirely infuse the corpse, arresting the decay.

Tollund Man's excellent preservation was due to a large amount of collagen fibres that were tanned by the moss in his dermis (inner) skin layer, as well as the keratin of his hair, fingers and toenails. The tanning effect also preserved the lacerations made by the noose and his wounds. Likewise, his brain was remarkably well preserved and his teeth were intact.

Like most of the other Danish bog bodies, Tollund Man lived and died around the midpoint of the period when ironwork emerged in Northwest Europe – between 500 BCE and 200 CE. Anaerobic bacteria, which don't need oxygen, concentrate iron deposits around bogs, leaving behind oily springs to show these iron 'bog ore' deposits.

After about 500 BCE, the peoples inhabiting Northwest Europe began to source and work this ore, needing about four football-sized lumps to make just one axe head. Since iron is easier to source than the tin and copper that make up bronze, and is more durable, its discovery transformed lives and social orders across Europe. The bogs that made this possible with peat and iron ore were therefore considered to be special and sacred places, and Tollund Man's area was rich in the stuff.

Peat bogs have preserved the bodies due to a cocktail of chemicals



Red Franz was named after his hair colour, which was dyed by acids in the peat

In the age of the bog people, the dead were often burnt on a pyre. Afterwards, their bones were gathered up, put in urns or wrapped in cloth and often buried under a mound with a few goods. To some cultures, cremation was bound with the belief that fire helped the body give up the soul so it could travel to the land of the dead to be reborn. Contrast this with the burials of the mummies, who were left in places where their remains were suspended with their souls unable to leave, and it suggests their deaths served a different purpose.

Before dying, the victims all received a last meal. Tollund Man and Grauballe Man enjoyed a grainy gruel, and the latter's contained a hallucinogenic fungus. The lack of fruits and vegetables shows that these men died in winter or early spring, possibly during the midwinter celebrations – a time connected to sacrifice. Perhaps their villages were on the edge of famine and the men were gifts for the gods in hope of a more successful harvest.

Little gold figures found in Danish bogs depict naked figures with belts and neck nooses, just like Tollund Man. The Oseberg Tapestry and picture stones, both dating from 700 to 900 CE, also show hangings as offerings to Odin, the god who hanged himself to gain power. Several centuries separate these Viking-age artefacts from the bog bodies, but even so, they indicate how the mummies may have been sacrificed as part of a cultic ceremony, where hanging and strangulation were often used.

Did you know?

Lindow Man is on display at the British Museum

Before becoming Britain's best-preserved bog body, Lindow Man ate a cooked mixed-grain cake known as bannock. Some of it was burnt, possibly singling him out for death. He also ate mistletoe, prized by the druids as a powerful medicine. From other clues, such as the fox fur around his arm and his well-kept fingernails, it's been speculated that he could have been an aristocrat or even a druid priest in training.

His unusual death – his remains show signs of bludgeoning, garrotting and strangling – and the year of around 60 CE make it possible that he was ritually sacrificed as a last resort against the Roman advance. General Gaius Suetonius Paulinus was marching towards the island of Anglesey, a druid stronghold, at the time, and the bog man's location was en route. Moreover, his death also coincided with Boudica's famous rebellion, pitching the Iceni tribe of present-day Norfolk against the Romans.

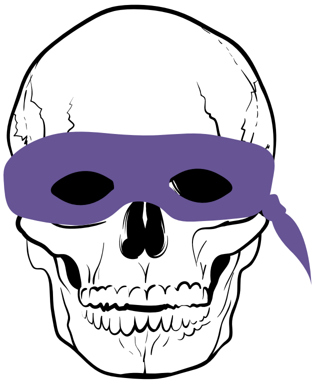
The gruesome manner of Lindow Man's death is echoed by Worsley Man, found in the outskirts of Manchester, who was buried around 100 CE. The idea of these people being sacrificed to avert Roman conquest is refuted by experts, who see them as murder victims. But if Lindow Man was murdered, why was he naked and in such a remote place? Similarly, if Tollund Man was hanged as a criminal, why was he so carefully buried?

The high status of some of these bog people can also be seen in Ireland. For instance, Old Croghan Man from County Offaly was tall and enjoyed a meat-rich diet and manicures. In County Meath, meanwhile, Clonycavan Man's hair was styled with an expensive gel made from plant oil and pine resin, likely imported

WHO WERE THE BOG PEOPLE?

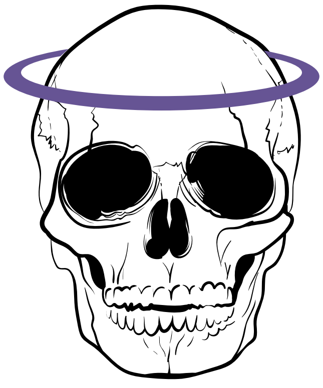
KINGS

Ireland's bog bodies, such as Old Croghan Man and Clonycavan Man from around the 3rd century BCE, are often found on boundaries separating tribal lands or below hills where kings were invested. Perhaps these men were kings who were sacrificed to appease the gods after failing their communities.



CRIMINALS

Bog bodies who were 'overkilled' by multiple assaults, and not cremated in the normal fashion, could have been criminals whose souls were trapped in their bodies as punishment. Roman historian Tacitus wrote of Germanic tribes taking cowards, poor fighters and evildoers and throwing them into marshes.



PROPHETS

Iron Age peoples may have seen disabled individuals as having powers of divination and prophecy. Kayhausen Boy had difficultly walking, and his killing by being stabbed in the throat could mean that his prophecies had failed or that the community divined their future prospects from his spilling blood.

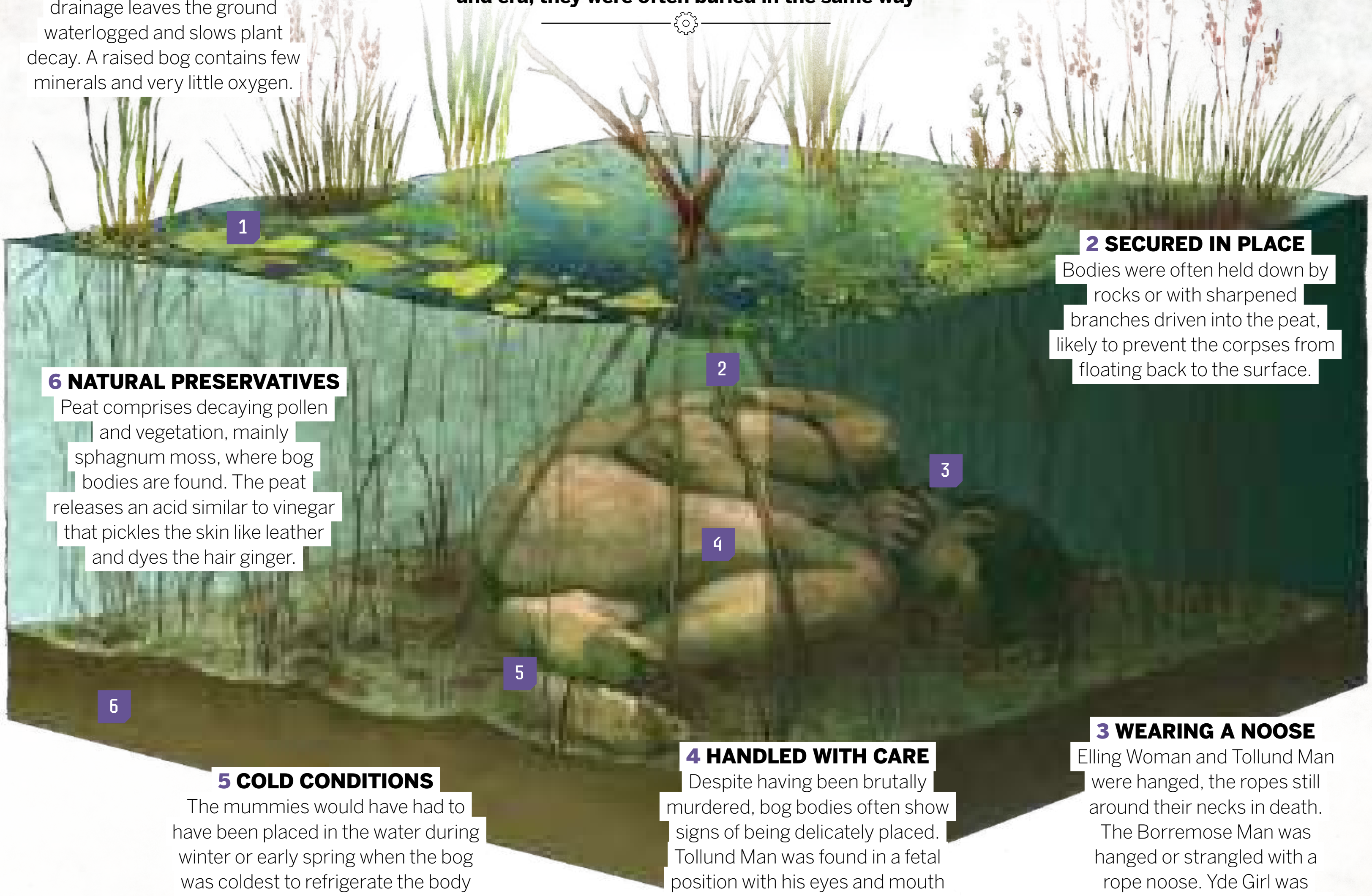
OUTSIDERS

Recent research indicates that bog bodies were considered unique in their villages, sometimes because they were foreigners or the hostages of raiding parties into other areas. This may have given them a special status that was thought to be more pleasing to the gods to whom they were sacrificed.

DID YOU KNOW? Tollund Man was at first mistaken for a murder victim, and police were called to investigate

MAKING A MUMMY

Though the bog bodies varied by country, culture and era, they were often buried in the same way



1 RAISED BOG
The best preserved bodies were all found in raised bogs, which form in basins where poor drainage leaves the ground waterlogged and slows plant decay. A raised bog contains few minerals and very little oxygen.

2 SECURED IN PLACE
Bodies were often held down by rocks or with sharpened branches driven into the peat, likely to prevent the corpses from floating back to the surface.

3 WEARING A NOOSE
Elling Woman and Tollund Man were hanged, the ropes still around their necks in death. The Borremose Man was hanged or strangled with a rope noose. Yde Girl was strangled with a woollen belt.

4 HANDLED WITH CARE
Despite having been brutally murdered, bog bodies often show signs of being delicately placed. Tollund Man was found in a fetal position with his eyes and mouth deliberately closed after his death.

5 COLD CONDITIONS
The mummies would have had to have been placed in the water during winter or early spring when the bog was coldest to refrigerate the body and prevent it from decaying.

6 NATURAL PRESERVATIVES
Peat comprises decaying pollen and vegetation, mainly sphagnum moss, where bog bodies are found. The peat releases an acid similar to vinegar that pickles the skin like leather and dyes the hair ginger.

Röst Girl, possibly the youngest bog body ever found

> **“Both were killed and deposited in bogs near hills where kings were invested”**

from France or Spain. Both men were killed and then deposited in peat bogs near hills where kings were invested or at the intersections of tribal boundaries.

Irish legends add to the idea that these two men were kings who were sacrificed to ensure the fertility of their lands, as they had failed their communities in hard times. The 4,000-year-old Cashel Man from County Laois, pinned in the bog with stakes, attests to a very ancient Irish tradition of ritual killing.

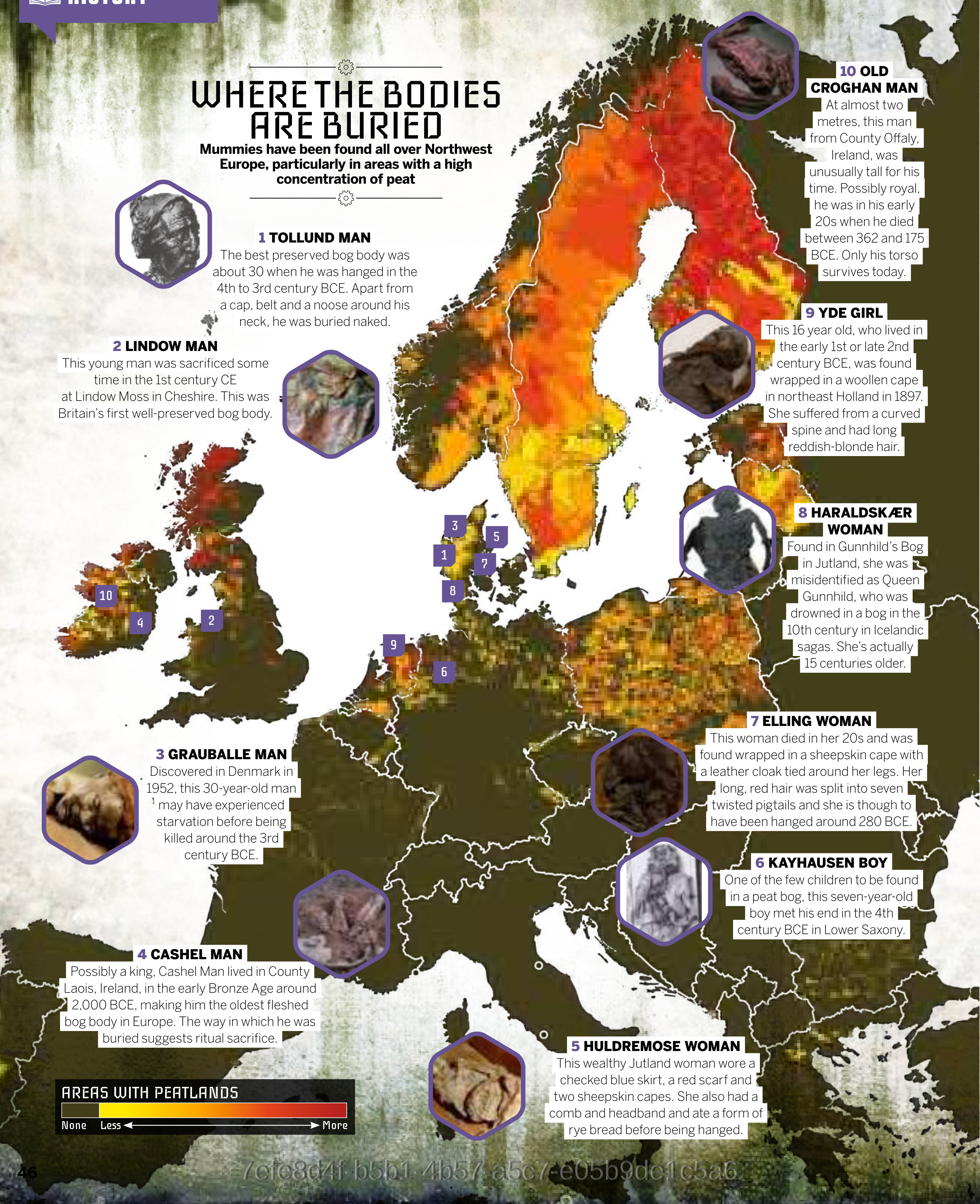
Dyed woollen clothes, amber beads and a bone comb testify to the wealth of Denmark’s Huldremose Woman, who met her violent end in approximately 150 CE. A recent analysis of her garments revealed their exotic foreign origin, which probably meant she had either traded or travelled abroad for them. Alternatively, she may possibly have emigrated across the channel or from further south to Denmark.

Similar unusual connections came from a study of Haraldskær Woman in 2014, kindling the belief that these two bog women were considered to be special because of their outsider status, and thus more efficacious as sacrifices. This theory argues that they were shamanic wise women who supposedly went willingly as gifts to the marsh goddess, blessing their communities with their own special sacrificial value as a result. Of course, it’s also possible that they were despised foreigners or prisoners of war.

According to Tacitus, a Roman historian, Germanic tribes punished cowards and the “disreputable of body” by drowning them in marshes under wattled hurdles, which may

WHERE THE BODIES ARE BURIED

Mummies have been found all over Northwest Europe, particularly in areas with a high concentration of peat



1 TOLLUND MAN
The best preserved bog body was about 30 when he was hanged in the 4th to 3rd century BCE. Apart from a cap, belt and a noose around his neck, he was buried naked.

2 LINDOW MAN
This young man was sacrificed some time in the 1st century CE at Lindow Moss in Cheshire. This was Britain's first well-preserved bog body.

3 GRAUBALLE MAN
Discovered in Denmark in 1952, this 30-year-old man may have experienced starvation before being killed around the 3rd century BCE.

4 CASHEL MAN
Possibly a king, Cashel Man lived in County Laois, Ireland, in the early Bronze Age around 2,000 BCE, making him the oldest fleshed bog body in Europe. The way in which he was buried suggests ritual sacrifice.

5 HULDREMOSE WOMAN
This wealthy Jutland woman wore a checked blue skirt, a red scarf and two sheepskin capes. She also had a comb and headband and ate a form of rye bread before being hanged.

6 KAYHAUSEN BOY
One of the few children to be found in a peat bog, this seven-year-old boy met his end in the 4th century BCE in Lower Saxony.

7 ELLING WOMAN
This woman died in her 20s and was found wrapped in a sheepskin cape with a leather cloak tied around her legs. Her long, red hair was split into seven twisted pigtails and she is though to have been hanged around 280 BCE.

8 HARALDSKÆR WOMAN
Found in Gunnhild's Bog in Jutland, she was misidentified as Queen Gunnhild, who was drowned in a bog in the 10th century in Icelandic sagas. She's actually 15 centuries older.

9 YDE GIRL
This 16 year old, who lived in the early 1st or late 2nd century BCE, was found wrapped in a woollen cape in northeast Holland in 1897. She suffered from a curved spine and had long reddish-blonde hair.

10 OLD CROGHAN MAN
At almost two metres, this man from County Offaly, Ireland, was unusually tall for his time. Possibly royal, he was in his early 20s when he died between 362 and 175 BCE. Only his torso survives today.

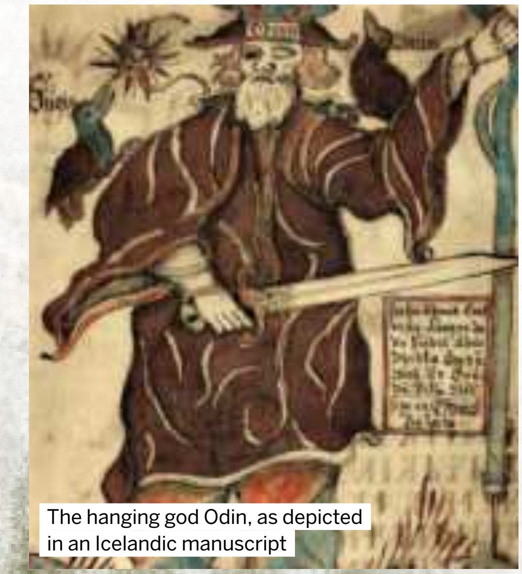
DID YOU KNOW? Bog bodies were created from some World War II deaths, such as Soviet pilot Boris Aleksandrovich Lazarev

have been what happened to Haraldskær Woman. This also occurred in Ireland and northern Germany. Since these ancient tribes didn't write about themselves, Tacitus is one of our best sources about them, although his records relied on secondhand sources regarding their customs since he never actually visited them himself. His accounts also serve to justify the subjugation of the 'barbarians' at the fringes of the Roman Empire.

In the most significant weather event since the Ice Age, Europe became dramatically colder and wetter after about 750 BCE. The resulting bad harvests produced may have stoked a widespread feeling that the angry gods had to be placated by human sacrifices. So-called 'water cults' saw a revival in Western Europe, with offerings of weapons starting at lakes and rivers – and perhaps these included humans when people were really desperate. Just how many of these killings were happening? Since water doesn't preserve skin and bone, we can only ever know the bog sacrifices, and further clues exist to signify the importance of making offerings to watery places.

The rarest and most prestigious of bog depositions in Denmark's pre-Roman Iron Age coinciding with the bog bodies are bronze and silver cauldrons, a number of which have been discovered. The finest is the Gundestrup cauldron, which may have originated as far away as the Balkans before it was dismantled and interred in the Danish bog around 100 BCE, close to the sites of three bog bodies. Across 13 silver plates, it depicts the mysteries of the mummies' religion, either the male or female pantheon of deities, or possibly religious officials such as druids or shamans.

One plate shows a large figure plunging warriors into a kind of cauldron while 'reborn' warriors on horses ride away in a procession. Another panel shows a cross-legged horned figure holding a torc and a snake – a shamanic god among animals. In Celtic mythology, the


The hanging god Odin, as depicted in an Icelandic manuscript

A PILGRIM'S PICKLING

Miranda Aldhouse-Green, emeritus professor of archaeology at Cardiff University, says that many of the bog people may have been on spiritual journeys before being killed

Recent research highlights the 'geographic outsider' status of two of the Danish bog bodies – the women of Huldremose and Haraldskær. Do you agree that this was the most important factor in their deaths?

This new interpretation, based on isotopic analysis, is very important for endeavours to understand who these people were in life. In no way does it detract from the idea of the special status according those who ended up as bog people.

The idea of the spiritual journey makes total sense to the notion that Haraldskær Woman was some kind of religious leader, even a shaman. Pilgrimage was important in the ancient world, and someone who had travelled widely would have been invested with exotic and powerful status. Not many people within Iron Age communities would have the opportunity to make such journeys; they would be expensive, time-consuming and potentially risky, so those undertaking them would not have done so lightly.

Do you think other bog bodies could have had a similar 'outsider' status?

I suspect this might be the case. I think I'm right in saying that there is evidence that Tollund Man also made a long journey in the months before he died. This idea has a particular interest in terms of the bog people who had some disability that made walking difficult, such as Yde Girl and Kayhausen Boy. For these individuals, a pilgrimage would itself have been a huge act of self-sacrifice.

Does scientific evidence support the theory that many bog people were ritually killed?

In speaking to colleagues involved in bog body research, particularly in Denmark, there is wide agreement that scientific techniques applied now serve to endorse and bolster ideas of ritualised deaths. Of course, it's impossible to be dogmatic and assume that all the bodies we know about died in sacrificial circumstances, but the highly choreographed killings, the overkill violence and the 'last suppers' of so many all seem to point to the choice for bog-based ceremonies being wrapped around with ritual behaviour.

Which is your favourite bog body?

One is Haraldskær Woman and the other is Clonycavan Man from Ireland. New examination of both has the potential for revealing many more secrets associated with seasonality, status and links with foreign lands. With Clonycavan Man, these links are symbolised by his exotic hair gel, imported from Southern Europe.

Since bog bodies are always found by accident, often damaging them, do you think it will ever be possible for them to be detected before they are disturbed?

This is something that I am actively considering. It should be possible to develop techniques for underwater and underground testing of areas of raised bogs where bodies have already been found. At present, likely sites for this include central Ireland, the Tollund marsh in Denmark and Lindow Moss in Cheshire.

Is it right to display these kinds of human remains in much the same way as other artefacts?

Ethical issues are important. These are people, not artefacts, and need to be accorded respect. If they are to be displayed, the model of excellence is the Tollund Man room in Silkeborg Museum, where he resides peacefully in a small room decorated as though it were a bog, and where only a few people can see him at a time.

Bog Bodies Uncovered

Miranda Aldhouse-Green's book, *Bog Bodies Uncovered: Solving Europe's Ancient Mystery*, is published by Thames and Hudson

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> “As the evidence grows, so scholarship tends more towards the idea of ritualised offerings”

The Huldremose Woman, who was found in Denmark in 1879

origins of cauldrons are always mysterious. As a symbol of rebirth, the cauldron is part of other Indo-European traditions and foreshadows the symbol of the Holy Grail, while its iconography shares motifs with ancient art from the Near East and even as far as India with its cross-legged shaman.

Most scholars believe that the cauldrons were votive offerings to the indigenous gods – perhaps because the earlier human sacrifices weren’t propitious enough for them and the deities required more precious gifts. The more valuable the sacrifice, the more pleased the gods would be. Even so, the possibility of how this and the other cauldrons were hidden to prevent them becoming the spoils of other tribes, later forgotten when the communities who interred them were displaced, cannot be ruled out. With no firsthand accounts to tell us for certain, we are only able to hazard conjectures. Yet as the evidence grows, so scholarship tends more towards the idea of ritualised offerings.

The greatest amount of Iron Age bog deposits in Denmark comprise swords, spearheads and shields that were bent or broken before being carefully arranged in bundles and placed in bogs or cast out into lakes. Serving as votive offerings to the gods, these weapons were usually the war spoils from military clashes between Scandinavians and Romans. Of Denmark’s many weapon-sacrifice sites, the most prominent is Illerup Ådal, where at least three deposits amount to thousands of items.

Julius Caesar, who related similar activities when he was in Gaul, corroborates the ritual purpose of these weapon sacrifices. Ultimately, for having supplied the weapons for these conflicts to armies on both sides, Roman merchants profited the most.

Bog bodies are not known to accompany these types of deposits. The Danish weapon sacrifices reached a peak of intensity between 200 and 450 CE, closely coincident with Roman expansion into Northern Europe and the waning of ritual bog killings in Denmark. Furthermore, the emergence of a political nucleus in eastern Jutland at the same time could also have been a significant factor in the decline of the bog bodies, as the weapon sacrifices replaced the human ones.

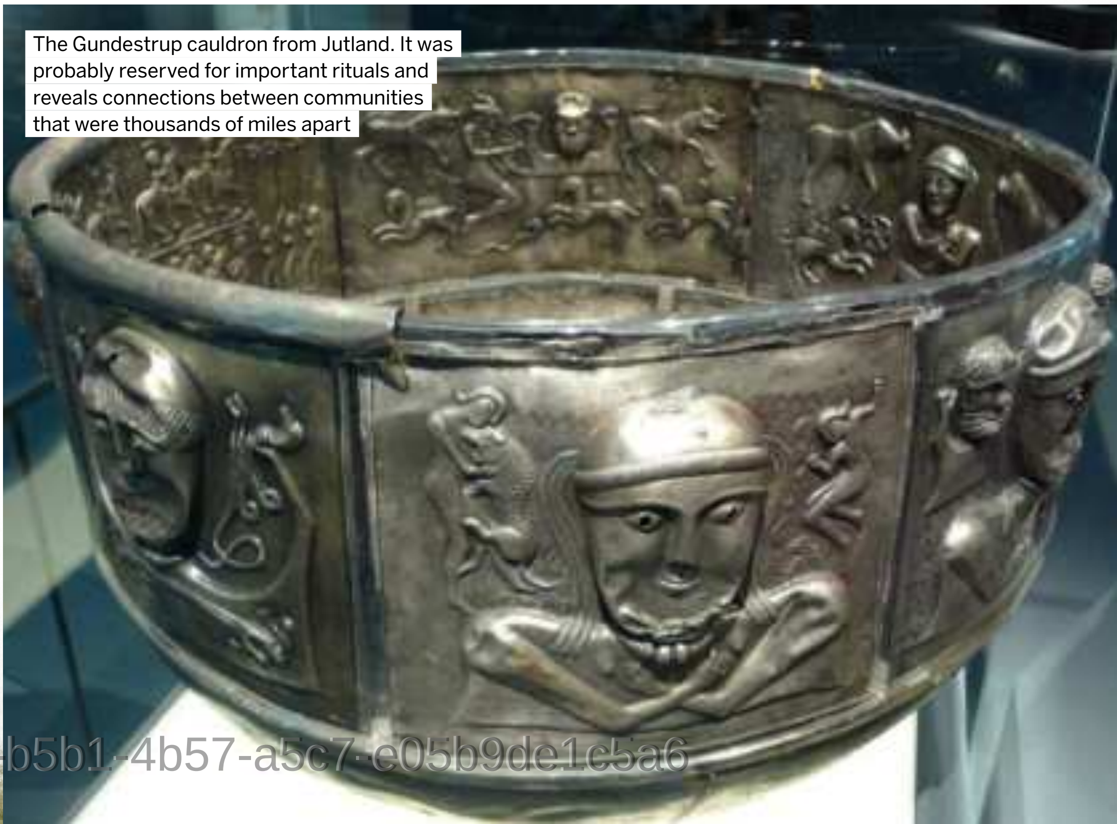
Somewhat surprisingly, Ireland’s bogs have also turned up a considerable amount of Iron Age butter. Resembling cheese, the so-called ‘bog butter’ usually comes in earthenware pots or wrapped in animal skins or bark. In 2013, a 5,000-year-old piece weighing some 45 kilograms was found in County Offaly, and a 35-kilogram chunk that is 3,000 years old was found in County Kildare in 2009. Around 300 more examples have emerged.

Since bogs make good natural fridges, it could simply be that the butter was deposited to preserve it, or even to improve the taste. Those brave enough to have tried recreations describe it as ‘gamey’ and ‘funky’. But if the intention was to retrieve it later, then why was so much butter left in the ground?

Perhaps they were survival caches, put away for leaner times and later forgotten. Yet since butter was valuable – and later used to pay taxes – it seems much more likely that they were sometimes buried as protection from thieves, or even made as sacred offerings to the gods.

The bog body phenomenon peaked around the 2nd century BCE before tailing off around the time that the Roman Empire was spreading into the north of Europe. It’s worth mentioning that this was also a time when political power was being consolidated in eastern Jutland.

The pattern of the bog body deaths in similar ways and by similar means suggests that despite the great distances between them, the peoples of Northwest Europe shared broadly similar perceptions about the sacred importance of ritual offerings made to watery places, even if the precise circumstances of individual bog bodies and depositions vary. These beliefs lasted for centuries, and even survive today whenever a wish is made before throwing a coin into a fountain or well. Out there, somewhere in the mires, there must be other bog bodies that can tell us even more about their world and why they came to be.



The Gundestrup cauldron from Jutland. It was probably reserved for important rituals and reveals connections between communities that were thousands of miles apart

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HEROES OF HISTORY

HOWARD CARTER

100 years ago, this archaeologist shot to worldwide renown when he discovered the tomb of the Egyptian pharaoh Tutankhamun

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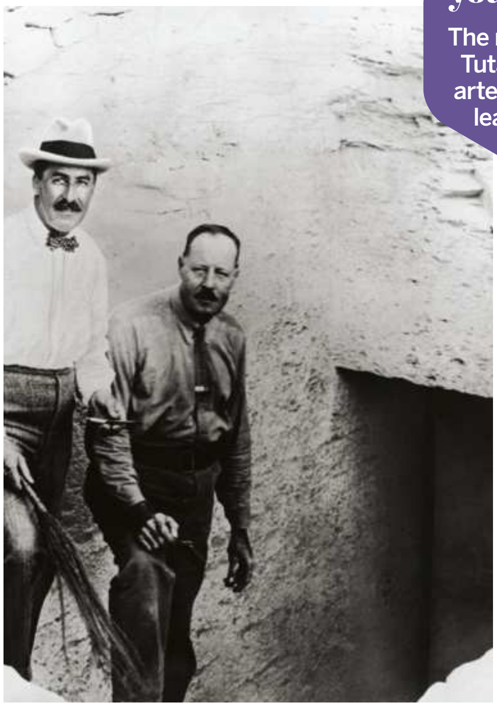


The discovery of the tomb of ancient Egyptian pharaoh Tutankhamun was made more famous because it was so well hidden, untouched by grave robbers and archaeologists alike for thousands of years. When it was unearthed a century ago, the mummified body and its decorated sarcophagus emerged fully intact. Many ancient tombs were uncovered in Egypt in the 20th century, but Tutankhamun's remains and treasures were the only ones to be excavated in their entirety.

Tutankhamun was a young pharaoh who ruled ancient Egypt for just a single decade, until around 1324 BCE. Howard Carter, the archaeologist who led the excavation of Tutankhamun's tomb, searched the landscape of Egypt for three decades before he found the pharaoh's final resting place.

Carter's career began in a wholly unlikely place, following the legacy of his artist father Samuel John Carter and developing an early talent for drawing and art. His father, who helped homeschool Carter, would often paint portraits of Egyptologists. As a result, and during his teenage years especially, Carter became intrigued by Egypt and the country's history – the first trip he made outside of England was to Alexandria, Egypt. By combining his artistic talents with his interest in Egyptology, Carter recreated the artwork that was discovered in the tombs of Middle Egypt. Some of the famous sites he visited, shadowing famous archaeologists, include Edfu, Thebes, and Abu Simbel.

His experiences in Egypt, which included working with renowned archaeologist William Flinders Petrie, helped him build upon his archaeological skills. Petrie wasn't greatly impressed by the youngster's excavation abilities, but Carter insisted on perfecting his restoration techniques. Someone who saw further potential in the young archaeologist was a wealthy English aristocrat called Lord

Above: Carter and his assistant Arthur Callender standing by the entrance to the tomb

Right main: Carter also worked as a translator during World War I

Right below: Carter pictured observing the sarcophagus of Tutankhamun in 1922

Did you know?

The most fragile Tutankhamun artefacts never leave Egypt

5 THINGS TO KNOW ABOUT HOWARD CARTER

1 SMALL FIND
It's thought that Tutankhamun's tomb was hard to find because of its small size. This may have been due to the pharaoh's unexpected death, which meant there was less time to prepare a tomb.

2 SUCCESS FROM EXPERIENCE
Carter had no formal education as an archaeologist, instead learning his skills while assisting with excavations.

3 BEYOND EXPECTATIONS
Speaking about the Tutankhamun tomb discovery, Carter said: "It was a sight surpassing all precedent, and one we never dreamed of seeing."

4 STUDYING THE LIVING
While in Egypt, Carter produced many paintings of the wildlife around him, focusing particularly on the birds.

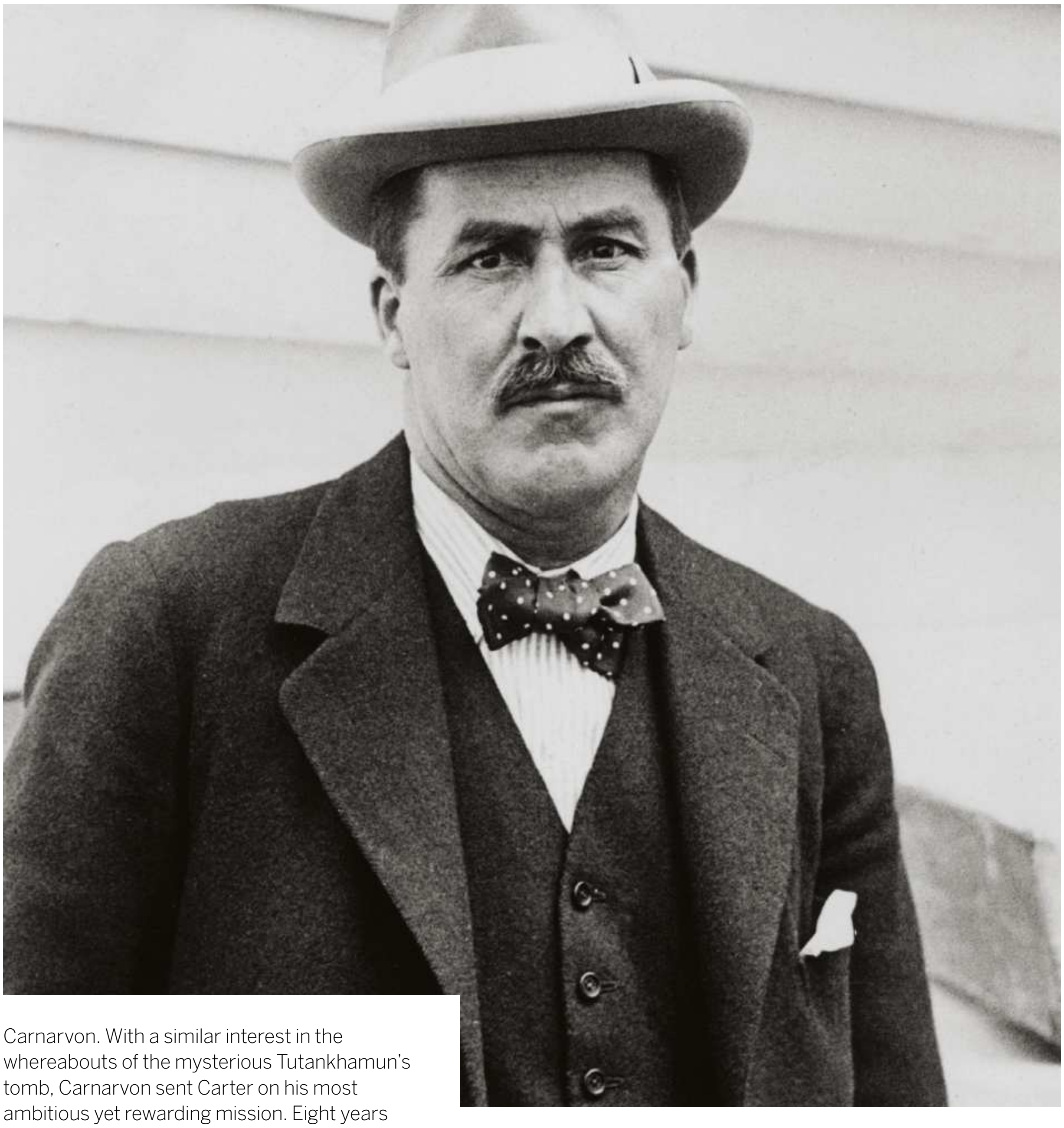
5 SECRET TRANSLATOR
During World War I, Carter worked as a translator to relay messages between French, British and Arab officials.

The BIG idea

FINDING A PHARAOH

The Valley of the Kings in Egypt is where pharaohs and other powerful figures were placed in tombs between the 15th and 11th century BCE. But by 1913 most archaeological experts had come to the conclusion that there was nothing left to excavate. Carter, however, thought there was more to be learned about King Tutankhamun and that hope of recovering him wasn't lost. In 1918, Carter began to thoroughly research the history of the king. By the beginning of November 1922 he had discovered the entrance to his tomb, and on 23 November the passageway leading to the tomb was uncovered. While the tomb itself appeared to have been undisturbed for 3,000 years, there was evidence of trespassers who entered close to the interior chamber.

The 'death mask' of Tutankhamun, who died at just 19 years old



Carnarvon. With a similar interest in the whereabouts of the mysterious Tutankhamun's tomb, Carnarvon sent Carter on his most ambitious yet rewarding mission. Eight years after Carnarvon granted Carter a licence to dig at the site where Tutankhamun's body was believed to lie, Carter and his team came across a large stone. When they moved the stone and searched below, they discovered a series of secret steps. These led to a mud-plastered doorway and the entrance to Tutankhamun's chamber. Among the tomb's tributes – golden jewellery, statues and boat ornaments that represented the journey to the afterlife – the DNA Carter discovered later helped identify other Egyptian mummies.

When Tutankhamun was discovered, DNA analysis didn't yet exist. But in 2010, following advancements in DNA profiling, his family's remains were matched with his reconstructed genetic information. Two previously anonymous mummies were found to be Tutankhamun's parents, while pharaoh Amenhotep III and queen Tiye were discovered to be his grandparents. During a study of Tutankhamun's DNA, scientists in Switzerland deduced that over half of all Western European men share a common ancestor with Tutankhamun.

A LIFE'S WORK

How did an artist become one of the world's most acclaimed archaeologists?

1874

On 9 May, Carter was born in London. He was the youngest of 11 children.

1874-1891

Due to being a 'sickly child', Carter lived with his aunt in Norfolk in his early years.

1891

At 17 he got a job as a tracer, drawing pictures of artefacts and other findings.

1892

After a year as a trainee tracer, Carter began working with Egyptologist Flinders Petrie.

1899

Carter became an inspector of monuments for Upper Egypt.

1907

He met archaeologist Lord Carnarvon and they began excavating together.

1914

The Egyptian Antiquities Service gave Carter and Carnarvon permission to dig in the Valley of the Kings.

1917-1922

Carter convinced Carnarvon to fund the search for Tutankhamun's tomb.

1923

A year after the tomb's discovery, Carter wrote about the findings in three volumes.

1939

On 2 March, Carter passed away at age 65 in London.

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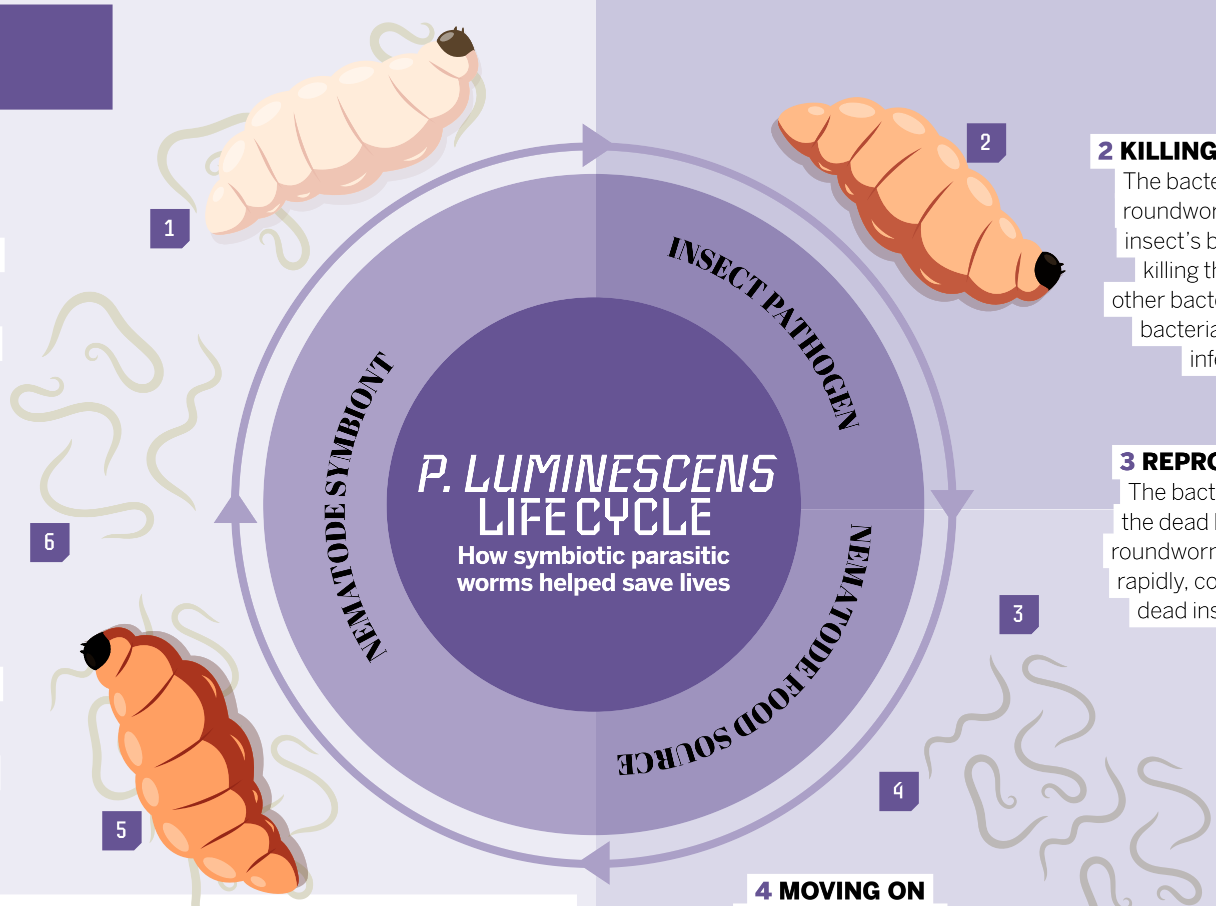

P. LUMINESCENS LIFE CYCLE
How symbiotic parasitic worms helped save lives
INSECT PATHOGEN
NEMATODE FOOD SOURCE
NEMATODE SYMBIONT
1
2
3
4
5
6

1 FINDING A HOST
The roundworm latches onto an insect in the injured soldier's wounds and burrows into it.

2 KILLING THE INSECT
The bacteria inside the roundworm invade the insect's blood vessels, killing the host and other bacteria - including bacteria that cause infection.

3 REPRODUCTION
The bacteria feed on the dead host and the roundworm reproduces rapidly, consuming the dead insect tissue.

4 MOVING ON
Having depleted the insect fully, the bacteria return to the roundworm.

5 ON THE HUNT
The roundworms, with bacteria still inside their bodies, search for a new insect to feed on.

6 THE CYCLE BEGINS ANEW
The cycle starts again when they locate and enter a new host.

ANGEL'S GLOW

Why injured Civil War soldiers glowed with a pale-blue light that seemed to heal their wounds

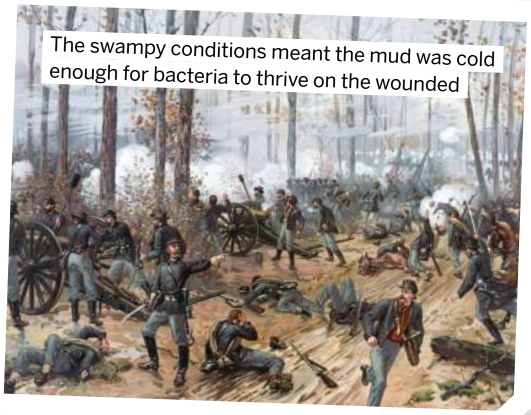
WORDS **JACK GRIFFITHS**

A vital victory for Union forces in the American Civil War, the 1862 Battle of Shiloh was fought in dreadful conditions. Bodies strew the battlefield, with field hospitals overrun on both sides. At night, when soldiers looked out at their fallen comrades and heard their cries of agony, a blue glow discharged from some of the troops. It was later discovered that those who had emitted the light were more likely to recover and heal quicker. They gave it the nickname 'Angel's Glow'.

It wasn't until almost 150 years later that a theory was put forward as to why this happened. William Martin may only have been 17 years old, but he and high-school friend Jonathan Curtis discovered why this ghostly pale-blue light helped clear wounds. The theory was that luminous parasitic roundworms in the ground entered the wounds and killed the bacteria that infected them. The roundworms, or nematodes, produced antibiotics that helped sanitise the injuries while consuming the microorganisms themselves. The bacteria produced by the nematodes was *Photorhabdus luminescens*, which as the name implies emits a glow.

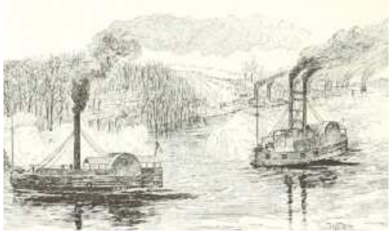
Only the soldiers that had hypothermia had Angel's Glow. This was because *P. luminescens* normally feasts on the bodies of cold-blooded insects that have a much lower body temperature. When the injured soldiers were warmed up in the hospitals, the bacteria died and the glowing stopped. But by then the wounded had a better chance to recover with fewer microbes infecting their injuries. The duo scooped a national science prize for their efforts and the phenomenon that amazed soldiers in 1862 was finally understood.

Did you know?
Union forces were led by future president Ulysses S. Grant


The swampy conditions meant the mud was cold enough for bacteria to thrive on the wounded

BATTLE OF SHILOH

Up to 20,000 soldiers were wounded in this key early engagement of the conflict. The battle was fought in a muddy field in Tennessee after a period of heavy rain had soaked the battlefield. The Confederate infantry launched a surprise attack on a camp, emerging undetected from dense forest. The aim of the Confederacy was to defeat the small Union forces before reinforcements arrived. Fierce fighting continued as night fell and field hospitals began to fill rapidly. The Confederate assault stalled and the conflict only lasted over a day as the Union forces, boosted by reinforcements, successfully reoccupied their camp and drove the Confederates back.


Union forces were supported from the Tennessee River

© Getty / Wiki: Thure de Thulstrup; Robert Underwood Johnson and Clarence Clough Buel

Photograph © Alex Chamberlin, 2021

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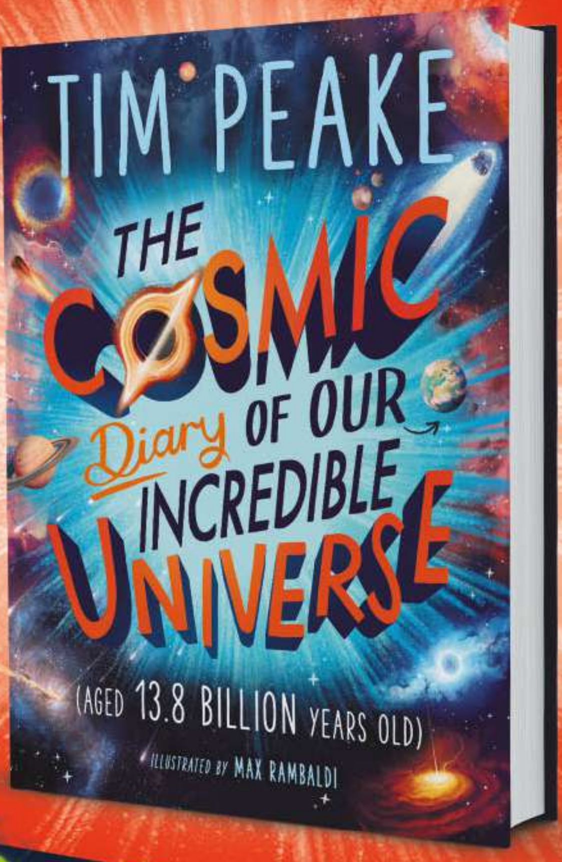
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[redacted]

What are
MICROPL

[redacted]

WORDS

DID YOU KNOW? Samples of Arctic sea ice have found 12,000 microplastic particles per litre

ASTICS?

5 TYPES OF MICROPLASTICS

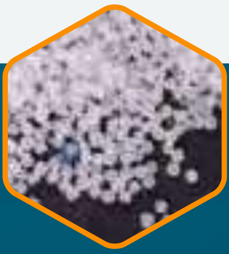
1 FIBRES
These thin, thread-like plastics come from fleece clothing and cigarette butts. One of the main ways these fibres enter lakes is through washing machines. One fleece jacket can release 2,000 during a single wash.

2 MICROBEADS
These tiny manufactured plastic spheres have a diameter less than one millimetre. They are often used to add exfoliating properties in soaps but are incredibly difficult to filter out of waste water due to their uniformly small size.

3 FRAGMENTS
When a larger piece of plastic breaks down over time, it becomes smaller microplastic fragments. Usually this is a result of exposure to the Sun's ultraviolet radiation.

4 NURDLES
Small pellets that are manufactured and used to make larger products. The small beads are melted and shaped into moulds of plastic products. Sometimes these escape into lakes and oceans during transportation.

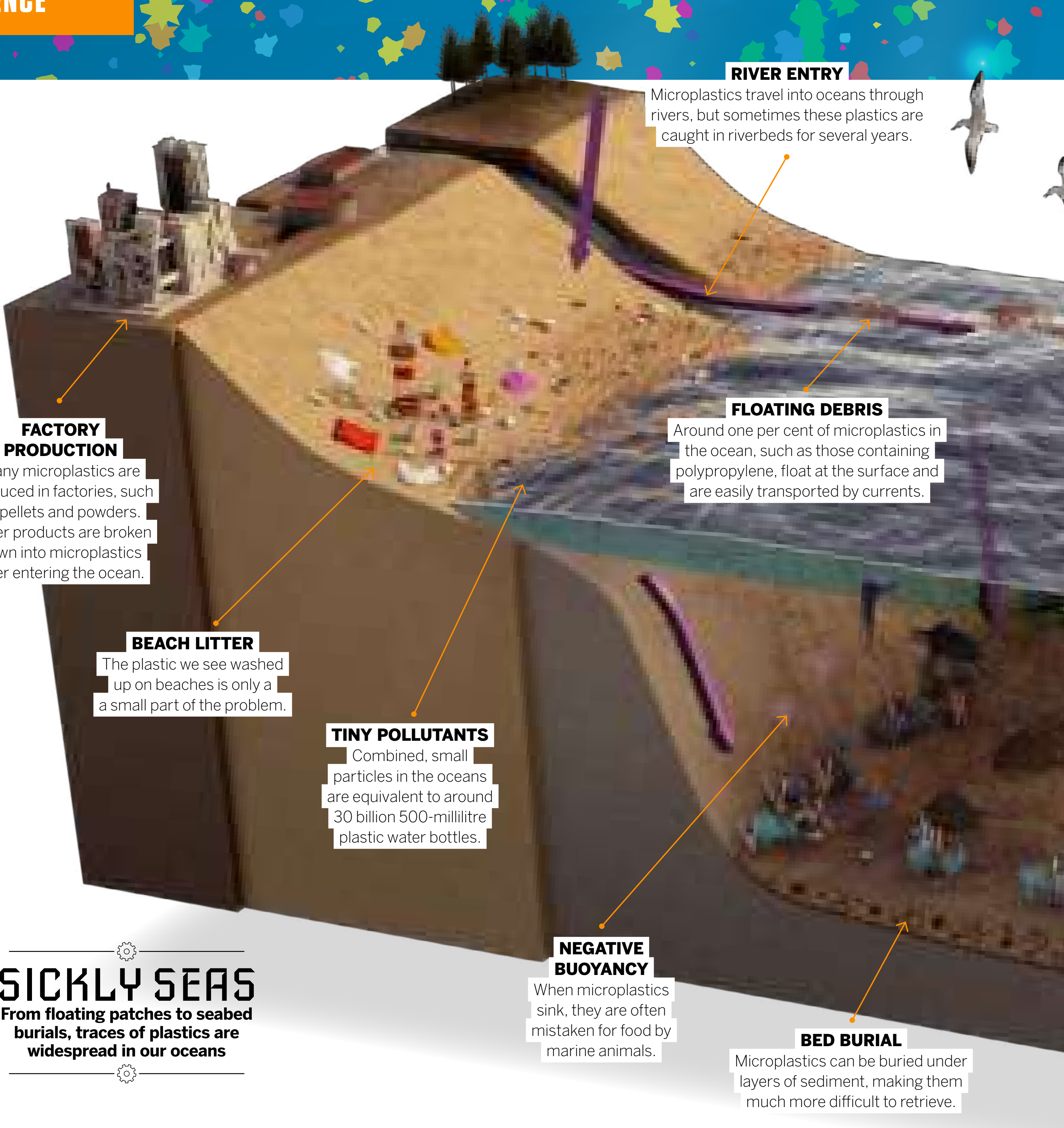
5 FOAM
This is the Styrofoam often used as packing protection in delivery boxes. This soft product can be broken down easily into microplastics.



© Getty / Alamy

SICKLY SEAS

From floating patches to seabed burials, traces of plastics are widespread in our oceans



RIVER ENTRY
Microplastics travel into oceans through rivers, but sometimes these plastics are caught in riverbeds for several years.

FACTORY PRODUCTION
Many microplastics are produced in factories, such as pellets and powders. Other products are broken down into microplastics after entering the ocean.

FLOATING DEBRIS
Around one per cent of microplastics in the ocean, such as those containing polypropylene, float at the surface and are easily transported by currents.

BEACH LITTER
The plastic we see washed up on beaches is only a small part of the problem.

TINY POLLUTANTS
Combined, small particles in the oceans are equivalent to around 30 billion 500-millilitre plastic water bottles.

NEGATIVE BUOYANCY
When microplastics sink, they are often mistaken for food by marine animals.

BED BURIAL
Microplastics can be buried under layers of sediment, making them much more difficult to retrieve.

BREAKING IT DOWN

How long do common plastic items take to decompose?

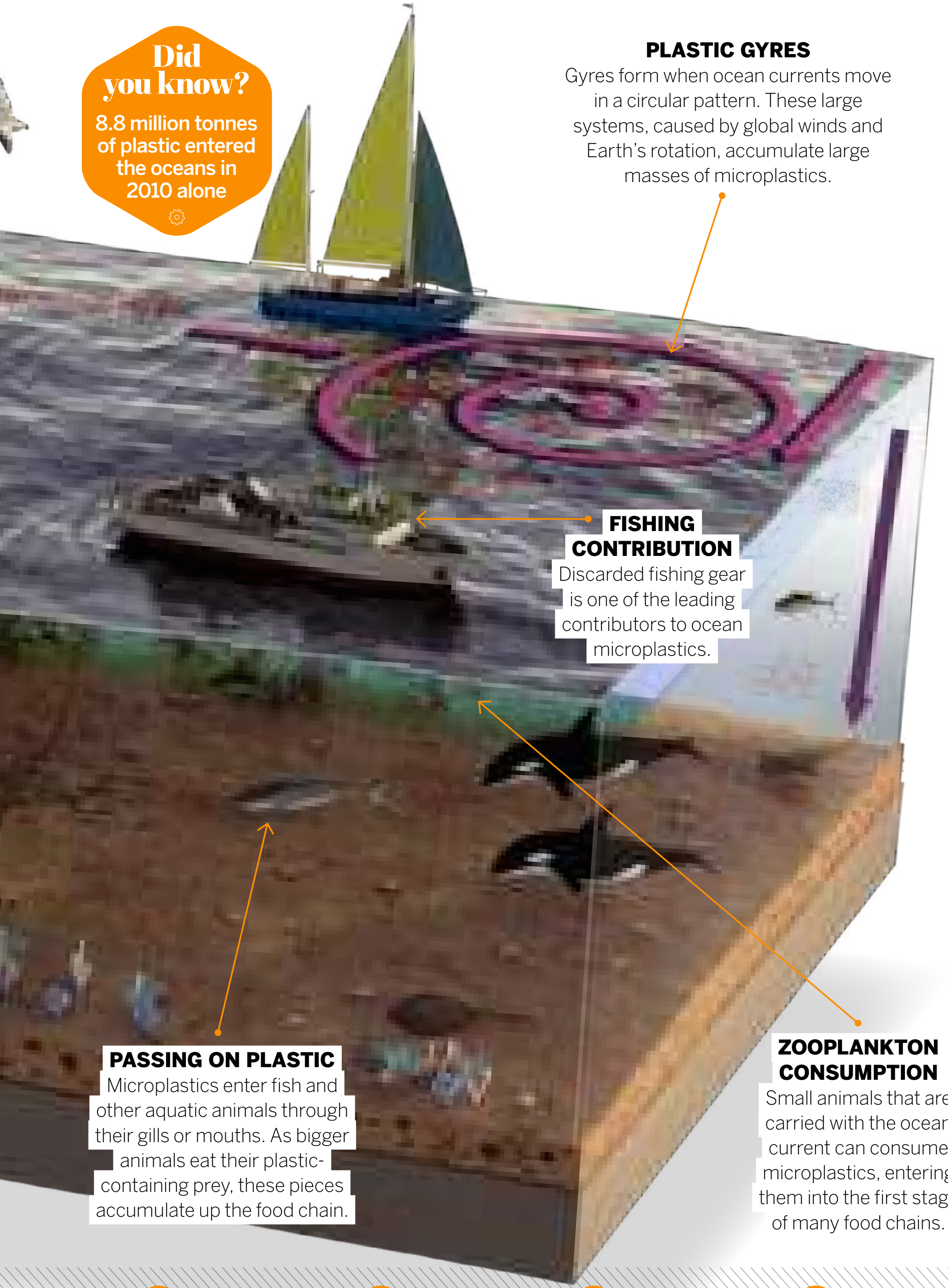
5 YEARS
Cigarette butts

20 YEARS
Plastic bags

30 YEARS
Coffee cups

200 YEARS
Straws

DID YOU KNOW? Around 68 per cent of fish ingest microplastics, each containing an average of 5.5 pieces



Did you know?
8.8 million tonnes of plastic entered the oceans in 2010 alone

PLASTIC GYRES
Gyres form when ocean currents move in a circular pattern. These large systems, caused by global winds and Earth's rotation, accumulate large masses of microplastics.

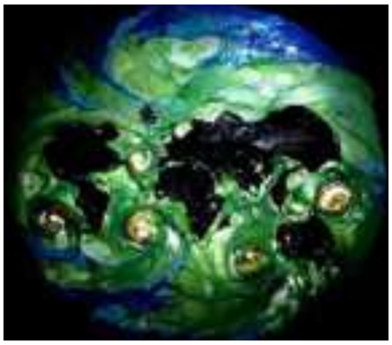
FISHING CONTRIBUTION
Discarded fishing gear is one of the leading contributors to ocean microplastics.

PASSING ON PLASTIC
Microplastics enter fish and other aquatic animals through their gills or mouths. As bigger animals eat their plastic-containing prey, these pieces accumulate up the food chain.

ZOOPLANKTON CONSUMPTION
Small animals that are carried with the ocean current can consume microplastics, entering them into the first stage of many food chains.

WHAT ARE OCEAN GARBAGE PATCHES

There are five main ocean gyres, or garbage patches, in Earth's oceans that have brought together many millions or billions of plastic pieces. In the largest of these, the North Pacific Gyre, there are an estimated 1.8 trillion pieces – that's about 250 pieces of plastic for every human on Earth. The other gyres are the North Atlantic Gyre, the South Atlantic Gyre, the South Pacific Gyre and the Indian Ocean Gyre. Although these patches are mostly made of plastic debris, they aren't exclusively plastic. Among the microplastic masses are larger pieces of rubbish, including fishing equipment, bottles and even mobile phones. Due to the circular movement of these patches, plastic items remain trapped in ocean gyres and are broken down by the Sun and the waves into microplastics.



The locations of the world's five main garbage patches are highlighted by the light circles

400 YEARS
Can holders

450 YEARS
Bottles

500 YEARS
Toothbrushes

500 YEARS
Nappies

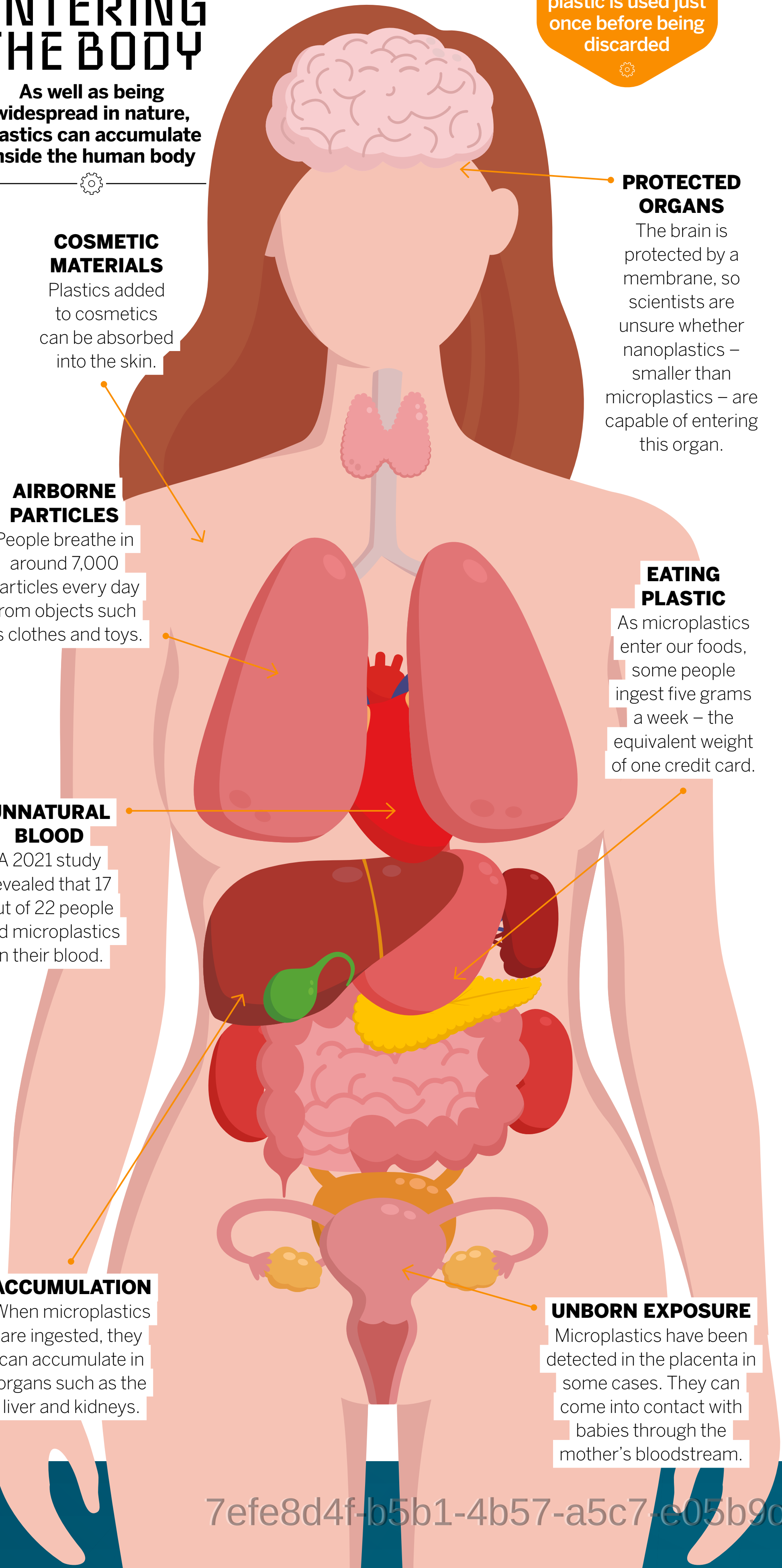
500 YEARS
Styrofoam

600 YEARS
Fishing lines

© Getty / Simon MAX Bannister / Illustration by Nicholas Forder

ENTERING THE BODY

As well as being widespread in nature, plastics can accumulate inside the human body



COSMETIC MATERIALS

Plastics added to cosmetics can be absorbed into the skin.

AIRBORNE PARTICLES

People breathe in around 7,000 particles every day from objects such as clothes and toys.

UNNATURAL BLOOD

A 2021 study revealed that 17 out of 22 people had microplastics in their blood.

ACCUMULATION

When microplastics are ingested, they can accumulate in organs such as the liver and kidneys.

PROTECTED ORGANS

The brain is protected by a membrane, so scientists are unsure whether nanoplastics – smaller than microplastics – are capable of entering this organ.

EATING PLASTIC

As microplastics enter our foods, some people ingest five grams a week – the equivalent weight of one credit card.

UNBORN EXPOSURE

Microplastics have been detected in the placenta in some cases. They can come into contact with babies through the mother's bloodstream.

Did you know?

40 per cent of plastic is used just once before being discarded

REDUCING EXPOSURE

Microplastics appear to be everywhere on the planet. But is it possible to avoid exposure to them in everyday life? Because you can't always see microplastics, you don't know when they're entering your body, but there are steps you can take to reduce the volume you come into contact with.

Firstly, you can change the containers that you eat or drink out of. For example, replace disposable coffee cups with stainless steel or glass ones and stop microwaving foods in plastic containers. Plastic can enter your food much more easily when heated, so transferring it into another dish can reduce how much plastic you accidentally consume. Plastic tea bags are capable of releasing 11.6 billion microplastics and 3.1 billion nanoplastics into your drink. To avoid this, you can replace them with loose leaf tea. Similarly, when choosing meals to eat, cutting down on seafood consumption can reduce how many of these particles enter your body.

Every time you wash clothes made of nylon, polyester or acrylic, you release hundreds of thousands of microfibres. To avoid releasing these microplastics, you can check the materials of clothes before buying them or install a filter into the washing machine to catch any that come loose. Additionally, when choosing cosmetics to apply to your skin, it helps to choose products that don't contain any microbeads or any form of plastic ingredient.

Tea bags are often made using polypropylene to seal them

DID YOU KNOW? A common crustacean, *Gammarus duebeni*, can break microplastics down into nanoplastics

REMOVING MICROPLASTICS

These technologies and techniques can help reduce microplastics' environmental impact

MUSSEL POWER

In 2021, studies carried out at the UK's Plymouth Marine Laboratory found that mussels – and in particular their poop – could help scientists remove microplastics from rivers and estuaries. The experiment, which focused on blue mussels, uncovered that because these creatures can filter microplastic pieces out from their bodies and into their faeces, they become buoyant when excreted.

By using this method, a quarter of all waterborne microplastics that these mussels encounter can be released to the water's surface for collection. The scientists discovered that 300 blue mussels can filter out 250,000 microplastics per hour using this method. Since the experiment, trials have begun to find an effective system for mussel microplastic removal. These involve submerging masses of mussels in containers, with nets attached to collect the microplastic-filled faeces.

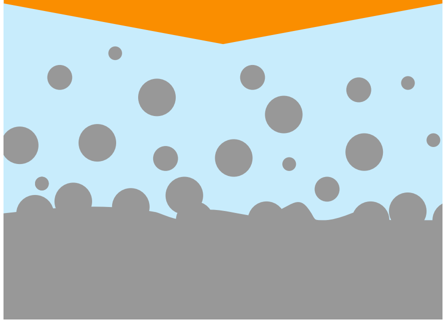
Blue mussels filter their food from the water

ROBOT REMOVERS

One potential solution for removing these tiny plastic pollutants is to deploy robots into the environment. In June 2022, a research paper from Sichuan University in China described a flexible, 13-millimetre-long fish-like robot that is both self-propelling and self-healing. The undisclosed soft material attracts the dyes and heavy metals in the microplastics to the robot fish through chemical bonds and electrostatics. Once in contact, the robot holds onto the microplastics and carries them until they are collected. If these fake fish get damaged while in the water, they can repair themselves and continue to depollute the seas, with a retained efficiency at least 89 per cent of what it was before it was damaged. More research is needed before these robots can be released on a large scale to make a difference, but it's an insight into the technology that could one day be working in the background to reverse what damage we've done to the environment.

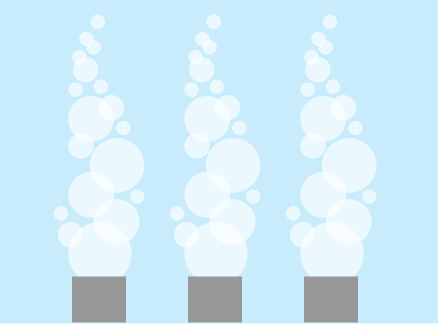
PREVENTING PLASTIC WATER

How do wastewater treatment plants remove microplastics?



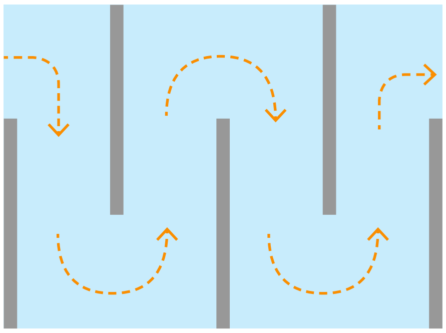
1 SEDIMENTATION

Water moves slowly through a sedimentation tank to allow suspended microplastic particles to sink and be filtered out of the water.



2 AERATION

Oxygen is added to cause growth of microorganisms and break down organics. The mesh used to collect waste products can trap up to 99 per cent of microplastics.



3 OXIDATION

An oxidant called ozone is added to water to break down contaminants such as microplastics. This is the most effective step to completely destroy them.

© Getty

Glasses or contact lenses are the most common treatment for astigmatism

Laser eye surgery is used to permanently correct eye disorders such as astigmatism

WHAT IS ASTIGMATISM?

How a change in the shape of the eye can alter the way people see the world

WORDS **SCOTT DUTFIELD**

Astigmatism is perhaps one of the most common eye conditions people experience. Around one in three people have been told that they have some sort of astigmatism. The condition comes from an irregularity in the shape of the eye's cornea. The cornea is normally a circular lens that works like a window, allowing light to pass through other parts of the eye, such as the lens and the retina. Among those with astigmatism, the shape of the cornea is slightly altered and is more oval, similar to the shape of an egg. The egg-like shape can either occur horizontally, when the cornea is wider than tall, or vertically, when it is taller than wide. Any alteration in the shape of the cornea affects the way light is projected into the eye, detected by optical sensory cells and interpreted by the brain. The result of such corneal alteration is blurred vision, headaches and eye strain.

Astigmatism is one of several eyesight disorders, the two most common being myopia (nearsightedness) and hyperopia (farsightedness). Similar to astigmatism, being either near or farsighted is related to the focal point that light reaches inside the eye. For farsighted individuals this point is behind the retina, and for nearsighted people is before. Astigmatism doesn't have a single focal point, which leaves objects both in the foreground and at a distance blurry.

There are several causes of astigmatism, including a genetic disposition for the condition, physical trauma or surgery. It can also be made worse by rubbing the eye. Rubbing the eye too much can stretch the cells that make up the cornea, leading to a change in its shape. Treating astigmatism is relatively simple. A good pair of corrective lenses can refocus light that enters the eye and point it in the right direction to offset the shape of the cornea. For more severe cases, laser-assisted in situ keratomileusis (LASIK) surgery uses a high-powered laser to precisely cut and reshape the cornea.

Did you know?

The cornea is around 560 micrometres thick

BONOBO BIFOCALS

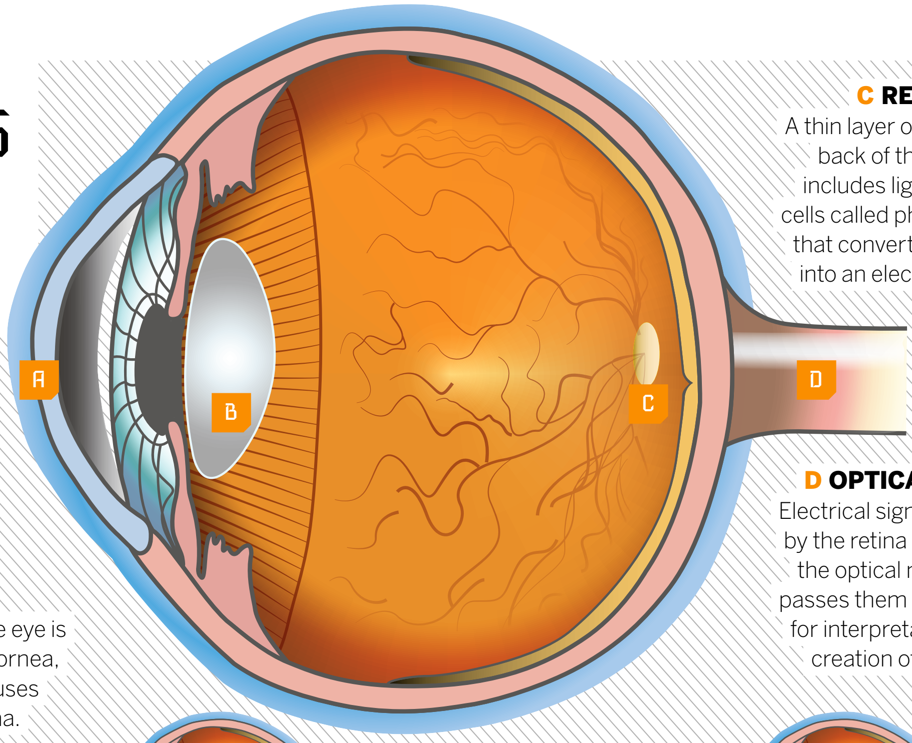
As we age, our eyesight naturally deteriorates and corneal astigmatism worsens, typically after the age of 50, and that applies to other primates, too. The eyesight of humankind's closest relative, the bonobo (*Pan paniscus*), becomes increasingly farsighted as they age. In 2016, researchers studied bonobos grooming members of their troop. What they discovered is that bonobos under the age of 30 looked into their grooming partners' fur from around ten centimetres. However, by the age of 45 that eyesight distance had gradually increased to around 40 centimetres, suggesting the older apes were farsighted.

Two bonobos engaging in daily grooming

DID YOU KNOW? The highest prevalence of human astigmatism can be found in Southeast Asia

SEEING THINGS DIFFERENTLY

How eyesight disorders alter our vision

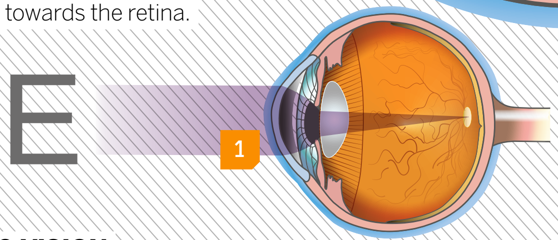


A CORNEA
A dome-shaped structure that acts as a physical barrier between the eye and the outside world, bending light and focusing it onto the retina.

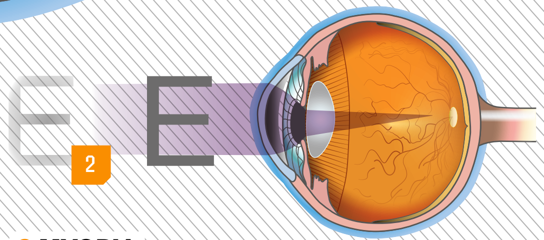
B LENS
Within the inner part of the eye is the lens. Along with the cornea, the lens bends and focuses light towards the retina.

C RETINA
A thin layer of tissue at the back of the eye that includes light-sensitive cells called photoreceptors that convert light energy into an electrical signal.

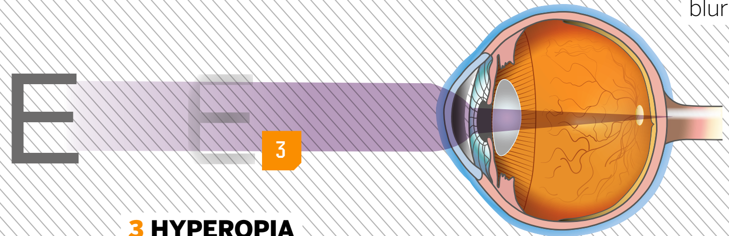
D OPTICAL NERVE
Electrical signals generated by the retina are passed to the optical nerve, which passes them onto the brain for interpretation and the creation of an image.



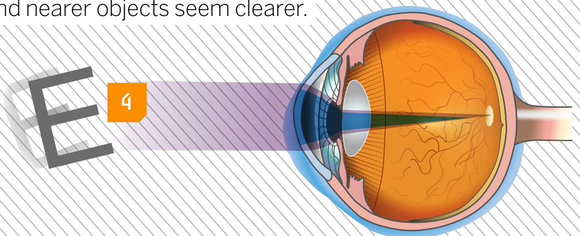
1 20/20 VISION
A typical eye receives light that is focused directly into the retina.



2 MYOPIA
When the eyeball is too long or the cornea is too curved, it causes light to focus just short of the retina. This means objects in the distance will appear blurry and nearer objects seem clearer.



3 HYPEROPIA
In instances where the eyeball is too short or the cornea isn't a smooth curve, light's focal point in the eye hits behind the retina, making objects in the distance clearer than those closer to the eye.



4 ASTIGMATISM
Due to a misshapen cornea, the focus point of light is split before and behind the retina, causing vision to blur at all distances.

CONE CORNEA

Astigmatism is one of the three most common eye disorders. However, when the eye's cornea becomes too thin and its shape bulges into a cone, the result is a condition called keratoconus. Affecting around one in 2,000 people, keratoconus is a severe disease where the collagen within the cornea decreases. Sufferers of keratoconus experience blurred vision, sensitivity to light and a sudden worsening or clouding of vision. The disease typically starts during puberty and progresses into a person's mid-30s, but the exact causes of keratoconus remain unclear to scientists. Research has shown that one in ten people with keratoconus share the condition with one of their parents. One of the most effective methods to treat keratoconus is a corneal transplant, whereby a donor cornea is inserted as a replacement.

Keratoconus caused the eye's cornea to bulge into a cone shape

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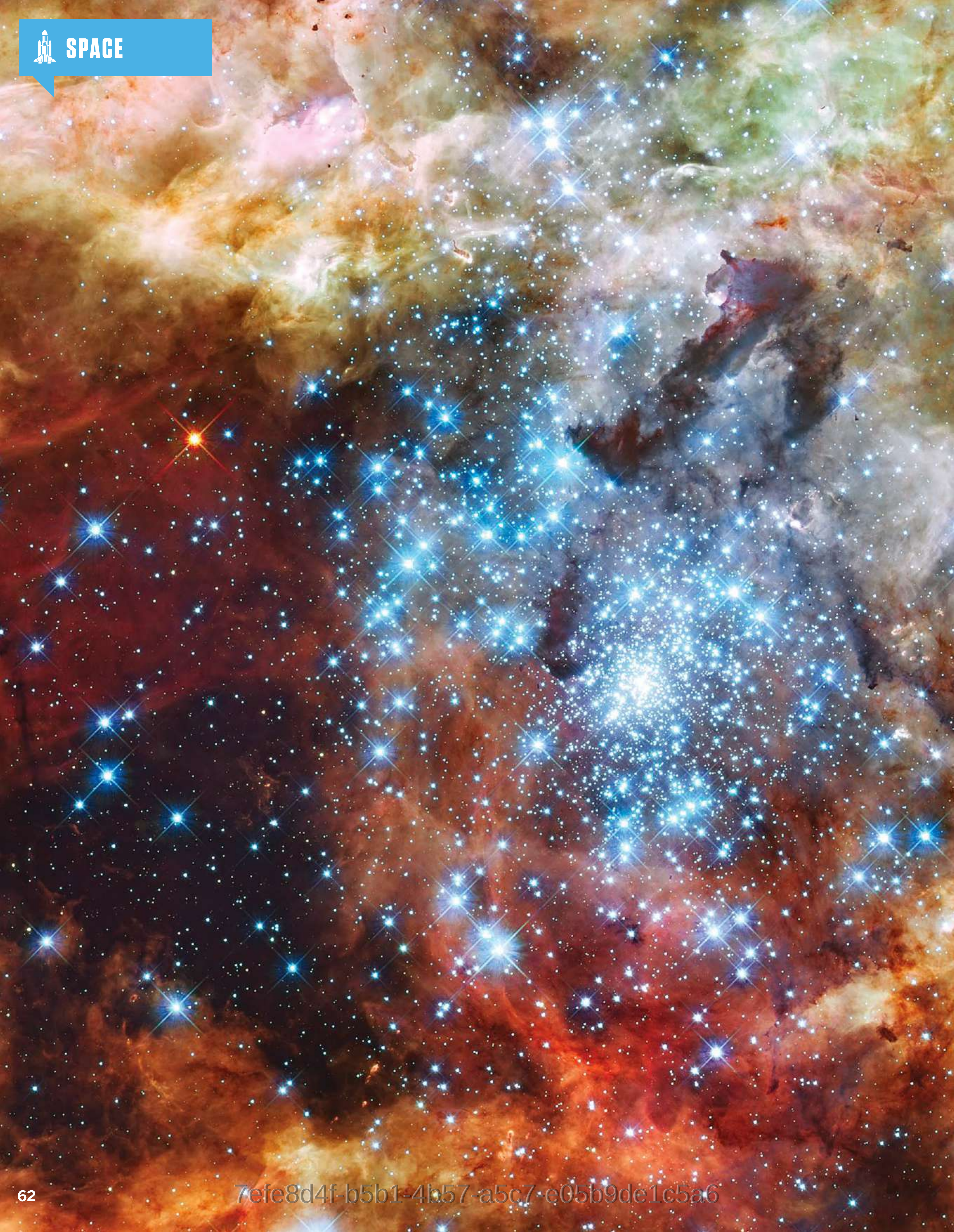

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DID YOU KNOW? The bright-blue stars Regulus and Spica were among the 15 Behenian stars used by medieval astronomers

BLUE STARS EXPLAINED

Take a look at the hottest stars in the galaxy, which live fast and die young

WORDS **ANDREW MAY**

To the naked eye, the stars in the night sky all look very similar, the main difference between them being that some are brighter than others. But if you look more carefully, you'll see that stars come in different colours. Most of them look white, but some are distinctly red in colour, while others are blue. A star's colour tells us about its temperature and mass, and blue stars are the hottest and most massive of all.

Did you know?

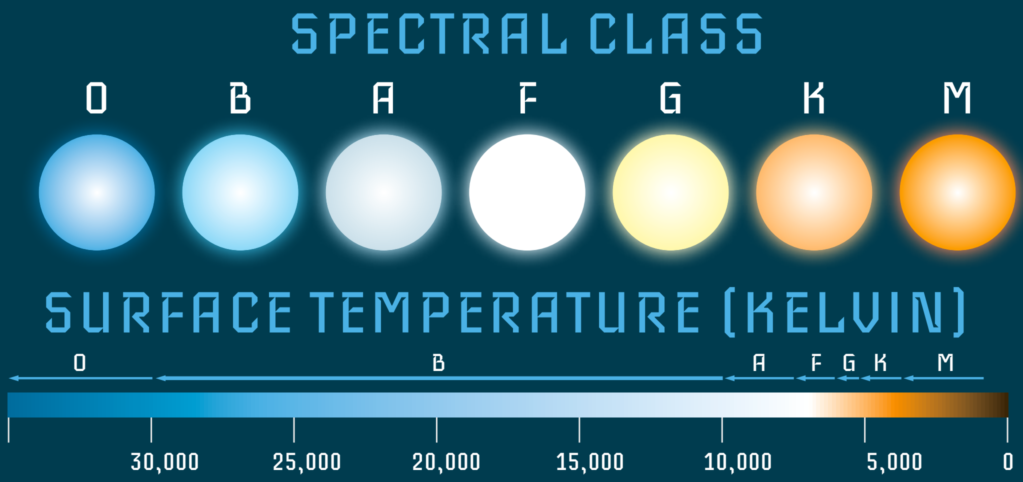
Blue stars are common in the spiral arms of galaxies

Any star that has three or more times the mass of our Sun will tend to look blue to our eyes. That's irrespective of other factors such as chemical composition; blue stars, yellow stars and red stars alike are made up of around 75 per cent hydrogen, 24 per cent helium and smaller amounts of other elements. But the fact that blue stars are more massive means they generally have higher intrinsic luminosities than other stars. This means they can be a long way away and still remain visible in the sky.

Blue stars are blue because they're very hot. This sounds wrong because in the everyday world – for example on weather maps and bath taps – red means hot and blue means cold. But blue light carries more energy than red light, which means it needs a hotter radiation source to produce it. This explains why blue stars are hotter than red stars, and also has a down-to-earth consequence if you've ever seen metal being heated up in a forge. First it glows red, then as it gets hotter it turns blue-white.

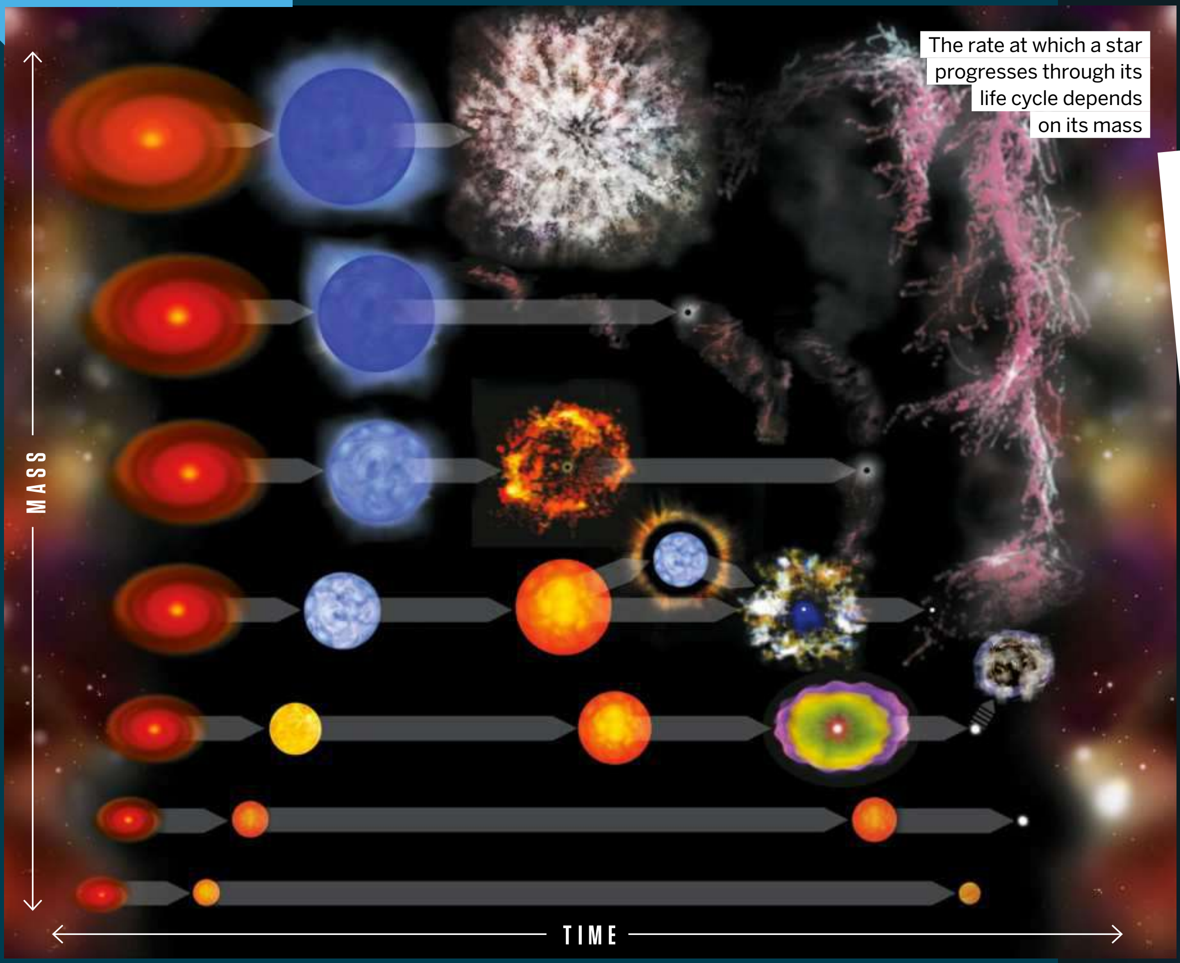
The high temperatures of blue stars, coupled with their high luminosity, means that they're constantly blasting out huge amounts of energy into space. As a consequence they burn through all their fuel very quickly, making them the shortest lived of all stars. For this reason, blue stars are most often observed near the star-forming regions where they were born. Although star-forming regions produce stars with a range of masses, they're not created in equal numbers, with low-mass stars vastly outnumbering high-mass ones. Coupled with the short lifetimes of the latter, this means blue stars tend to be scarce. Even so, we see quite a lot of them in the night sky, mostly because the ones that do exist are so luminous.

To mention just three well-known blue stars, there's Regulus, the brightest star in the constellation Leo; Spica, the brightest star in Virgo and Rigel, the brightest in Orion. As seen from Earth, all three stars appear similar in brightness, even though they're located at very different distances from us – 79, 250 and 860 light years respectively. This reflects the fact that blue stars come in different types depending on where they are in their evolutionary life cycle. Regulus is a main sequence star, Spica a blue giant and Rigel a blue supergiant.



Blue stars belong to classification groups O and B, with surface temperatures above 10,000 Kelvin

© NASA/Hubble



The rate at which a star progresses through its life cycle depends on its mass

The brightest stars in the Pleiades cluster are very young blue stars

HOW THEY EVOLVE

All stars go through life cycles, changing their appearance and behaviour on a timescale much too slow for us to observe directly. Most of the stars we see are in the 'main sequence' phase of their evolution, in which they convert hydrogen into helium through nuclear fusion. The amount of time they spend in this phase – and what happens afterwards – depends on the star's mass. The highest mass stars, greater than three times the Sun's mass, appear blue in colour when they're on the main sequence. They get through all their hydrogen fuel more quickly than lower mass stars.

As a blue star nears the end of the hydrogen-burning main sequence phase, it enters a relatively brief transitional state as a higher luminosity blue giant. As it progresses through this phase, the core temperature steadily rises until it's high enough to trigger the fusion of helium into heavier elements such as carbon and oxygen. This causes the star to enter an even brighter phase as a blue supergiant. These stars have truly enormous luminosities – for example, blue supergiant Rigel emits 60,000 times as much energy as our Sun.

We've explained that blue stars are blue because they're very hot and that their high temperatures mean they burn fuel much faster than other stars, so the fact that they started out with a limited supply of fuel suggests we should never see any old blue stars. Yet such stars, known as 'blue stragglers', do in fact exist. These are hot blue stars that are still on the main sequence even though they're located in star clusters that we know to be very old. The most likely explanation is that blue stragglers are old red stars that have been rejuvenated by new material falling into them from a binary companion.

Did you know?

Fewer than 0.1 per cent of stars are blue supergiants

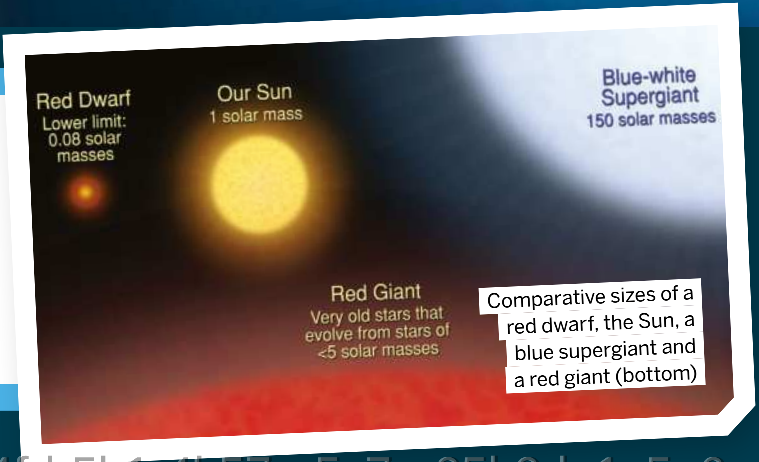
Very large blue stars may suck material from binary companions

BLUE GIANTS

The basic definition of a 'giant' star is one that is more luminous than a main sequence star. As the name suggests, part of the reason for this is simply that such stars are enormous in size. That's particularly true of the most common kinds of giant stars: red giants. Most stars, including our Sun, will eventually end up as red giants, and that's the case with blue stars too. Earlier in their lives, however, the latter will have spent time as blue giants and supergiants, and these are 'giants' due as much to the huge amount of energy they

DID YOU KNOW? Blue stars have such short life spans, it's unlikely that complex life would develop on their planets

radiate as to their physical size. Rigel, for example, a blue supergiant in the constellation of Orion, is 'only' 79 times the diameter of our Sun, compared to more than 550 times in the case of the red supergiant Betelgeuse in the same constellation.


Red Dwarf
Lower limit: 0.08 solar masses
Our Sun
1 solar mass
Blue-white Supergiant
150 solar masses
Red Giant
Very old stars that evolve from stars of <5 solar masses

Comparative sizes of a red dwarf, the Sun, a blue supergiant and a red giant (bottom)

5 FACTS ABOUT BLUE STARS

1 RECORD HOLDER
The most massive star observed to date is the blue supergiant R136a1, which contains at least 265 times as much matter as our own Sun.

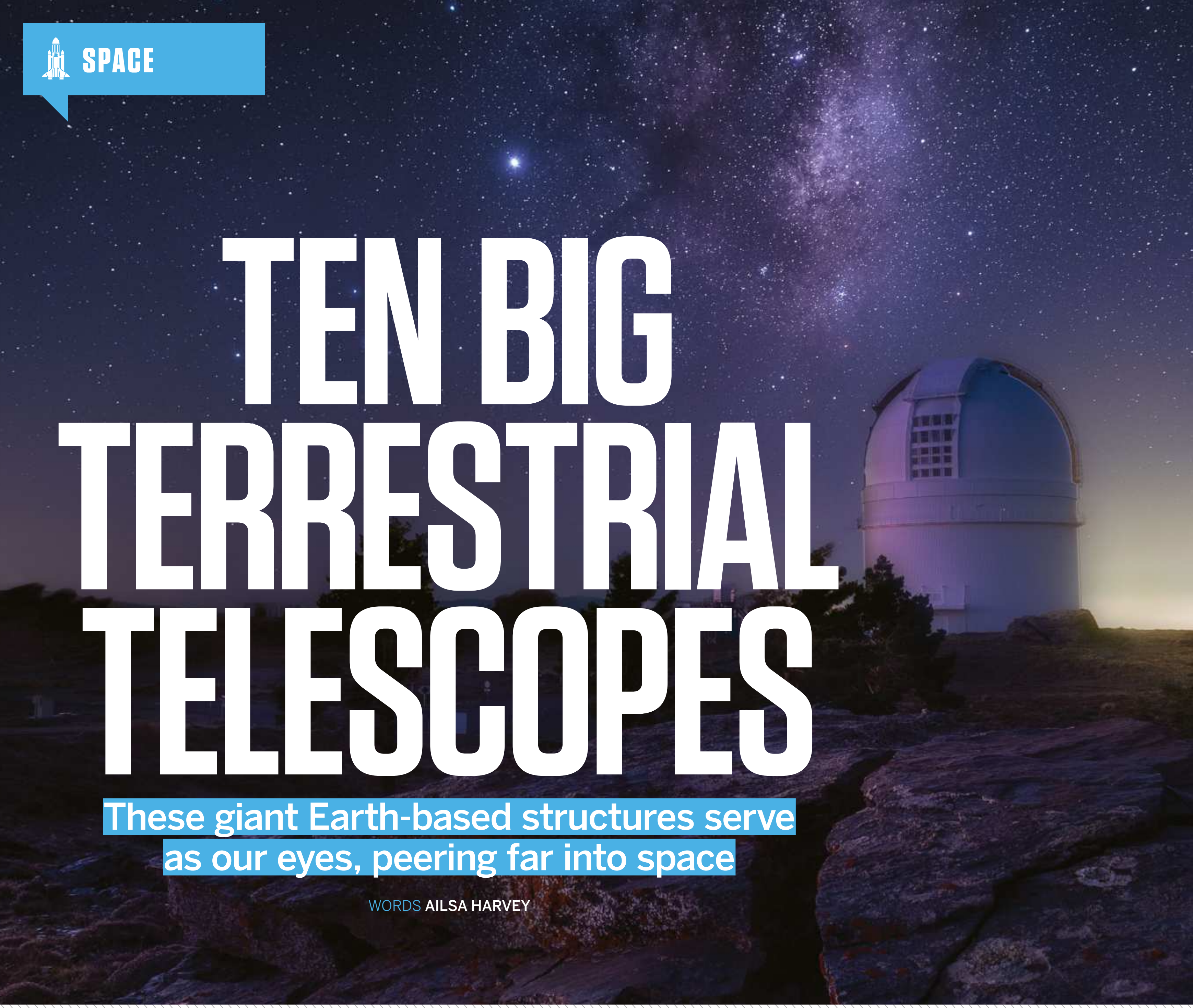
2 UNSTABLE STARS
Blue supergiants can become so bright that the outward pressure of radiation exceeds the inward pull of gravity, causing them to eject matter into space.

3 BLUE-WHITE
The next hottest stars after O- and B-type blue stars are A-type blue-white stars, including several well-known examples such as Sirius, Vega and Altair.

4 ULTRAVIOLET RADIATION
Although we perceive O- and B-type stars as being in the blue part of the spectrum, the peak of their output actually occurs at even shorter ultraviolet wavelengths.

5 BLUE GALAXIES
Galaxies that have little ongoing star formation, such as elliptical galaxies, tend to look red, while spiral galaxies, which feature many more young, hot stars, look blue.

© NASA / Getty / European Southern Observatory / Chandra Harvard



TEN BIG TERRESTRIAL TELESCOPES

These giant Earth-based structures serve as our eyes, peering far into space

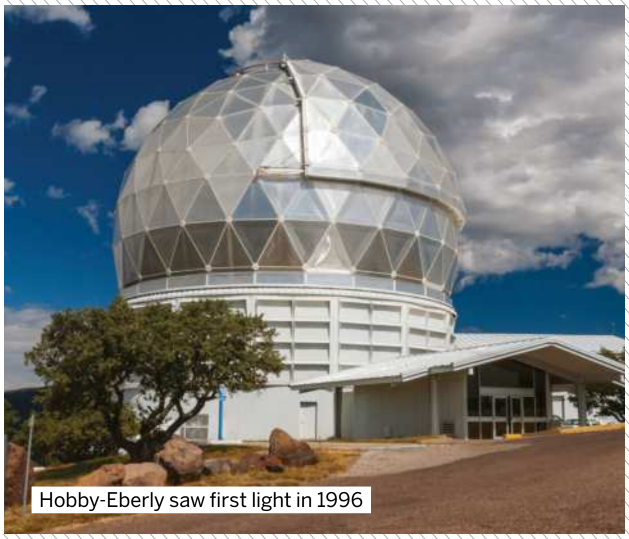
WORDS **AILSA HARVEY**

HOBBY-EBERLY

Location: **Texas** Type: **Optical**
Diameter: **Ten metres**

10 Before its success as one of the world's largest optical telescopes, Hobby-Eberly's design was unique. One element that helped make it stand out from existing telescopes is that its mirror is always tilted 55 degrees up from the horizon. This might sound restricting, but its rotating mechanism means it can still observe 70 per cent of the visible sky. The telescope's mirror has 91 hexagonal segments to collect visible light.

The most noteworthy discovery by Hobby-Eberly was observing light that originated from a quasar so far away that Earth was only an eighth of its current age when this light began travelling towards us. A quasar is an incredibly bright object that gains its energy from a supermassive black hole.



Hobby-Eberly saw first light in 1996

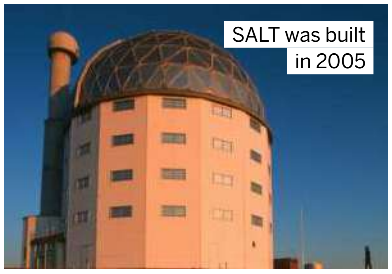
DID YOU KNOW? If our eyes had the viewing power of the GTC, we would be able to see car headlights in Australia from Spain

SOUTH AFRICAN LARGE TELESCOPE (SALT)

Location: **Karoo, South Africa**
Type: **Optical**
Diameter: **11.1 by 9.8 metres**

9

SALT's design appears almost identical to Hobby-Eberly's because it was inspired by the success of its predecessor. SALT has the same number of hexagonal panels as Hobby-Eberly, but was redesigned to improve its field of view and image quality. The mirrors also have higher sensitivity to short wavelengths due to the additional layers of metal added to them. Among SALT's top discoveries is the first white dwarf pulsar, a fast-spinning stellar remnant.


SALT was built in 2005

The Keck Observatory sits at an altitude of 4,145 metres

KECK TELESCOPES

Location: **Mauna Kea, Hawaii** Type: **Optical and infrared**
Diameter: **Ten metres**

8

Although based on land, the twin telescopes at the Keck Observatory can see farther into space than the famous Hubble Space Telescope. This results in around a quarter of the observations made by US astronomers being achieved using Keck, and it's therefore considered the most scientifically productive of all land telescopes.

By incorporating optical and infrared telescopes, the observatory produces clear images in the visible-light spectrum, but also allows astronomers to see deeper into space using the infrared imagery. Some of the incredible imagery uncovered at the Keck Observatory includes the birth of stars, which can produce a visible glow and also heat up surrounding gas, which can be detected using infrared detectors.

The observatory is positioned near the equator and at the top of the dormant Hawaiian volcano, Mauna Kea. There are 36 mirrors that make up each telescope, joined together to make one large panel. Concealed in insulated domes, the two telescopes operate at temperatures slightly below freezing to prevent heat from interfering with the infrared images.

Did you know?

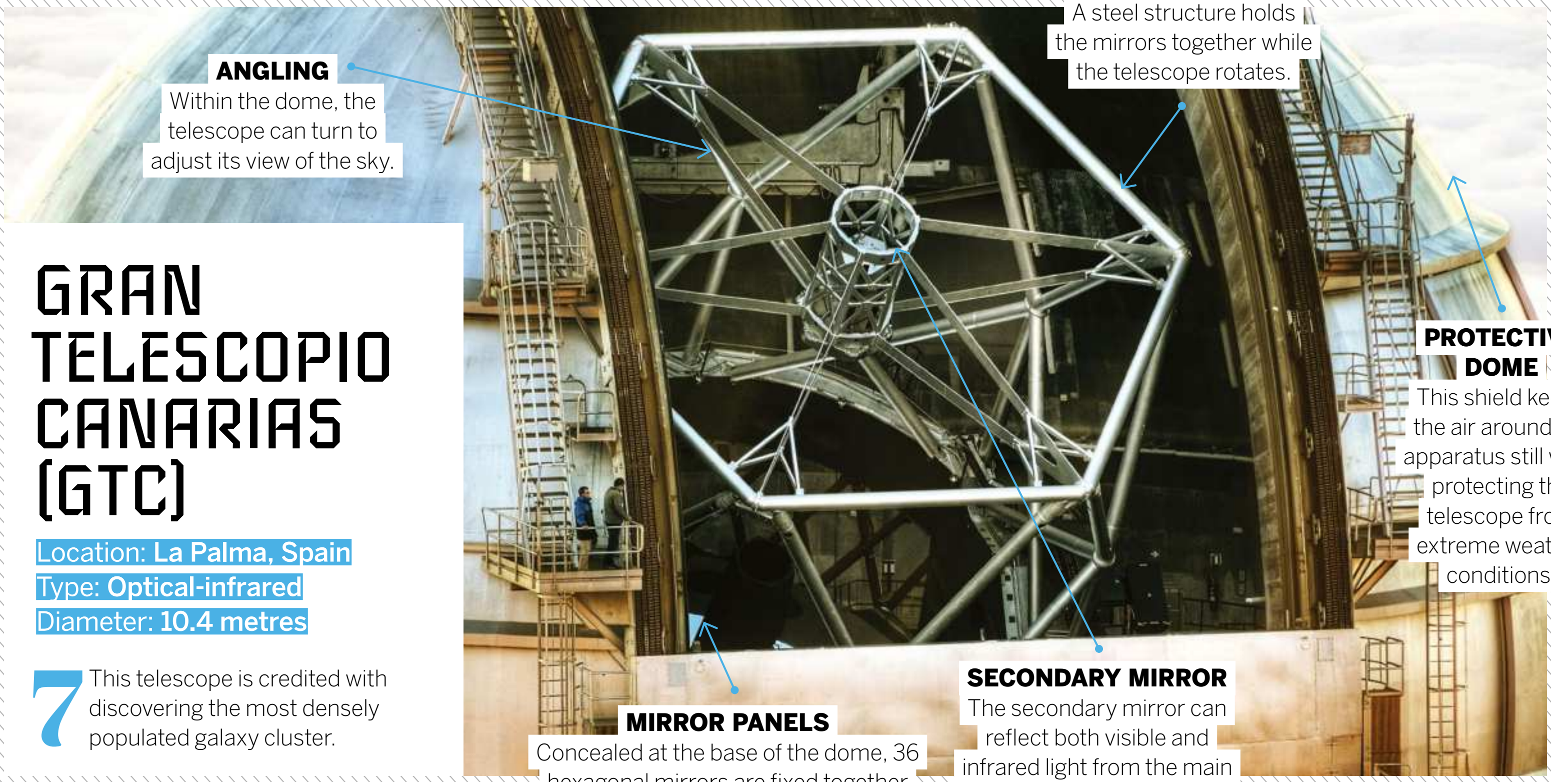
The Atacama Desert is the world's best dark-sky site

GRAN TELESCOPIO CANARIAS (GTC)

Location: **La Palma, Spain**
Type: **Optical-infrared**
Diameter: **10.4 metres**

7

This telescope is credited with discovering the most densely populated galaxy cluster.



ANGLING
Within the dome, the telescope can turn to adjust its view of the sky.

TELESCOPE MOUNT
A steel structure holds the mirrors together while the telescope rotates.

PROTECTIVE DOME
This shield keeps the air around the apparatus still while protecting the telescope from extreme weather conditions.

SECONDARY MIRROR
The secondary mirror can reflect both visible and infrared light from the main mirror to focus it.

MIRROR PANELS
Concealed at the base of the dome, 36 hexagonal mirrors are fixed together to form one large light collector.

© Getty

ATACAMA LARGE MILLIMETER/ SUBMILLIMETER ARRAY (ALMA)

Location: **Atacama Desert, Chile** Type: **Radio** Diameter: **12 metres**

6 ALMA is made up of 66 radio telescopes, with 54 of these measuring 12 metres in diameter and the remaining 12 seven metres. Collectively known as an astronomical interferometer, each of these antennae work together to create one image. When this array is used in different combinations, the range of visibility varies. This is essential for targeting the desired galactic areas. One of the groundbreaking discoveries made by ALMA was the most distant oxygen in space. This is a record that these telescopes have broken more than once.

The furthest detection of oxygen in space was 13.28 billion light years away, and evidence of this was picked up by ALMA in 2018. Due to the expansion of the universe, the infrared light that had been emitted from this oxygen was converted into microwaves as it stretched. The signal came from ionised oxygen in the galaxy MACS1149-JD1.

Chile's Atacama desert is cloudless most nights

THIRTY METER TELESCOPE (TMT)

Location: **Mauna Kea, Hawaii**
Type: **Optical-infrared**
Diameter: **30 metres**

4 This project is currently in progress as part of an international collaboration between Japan's National Institutes of Natural Sciences and National Astronomical Observatory, the California Institute of Technology and the University of California, the National Research Council Canada, National Astronomical Observatories of the Chinese Academy of Sciences and the Department of Science and Technology of India.

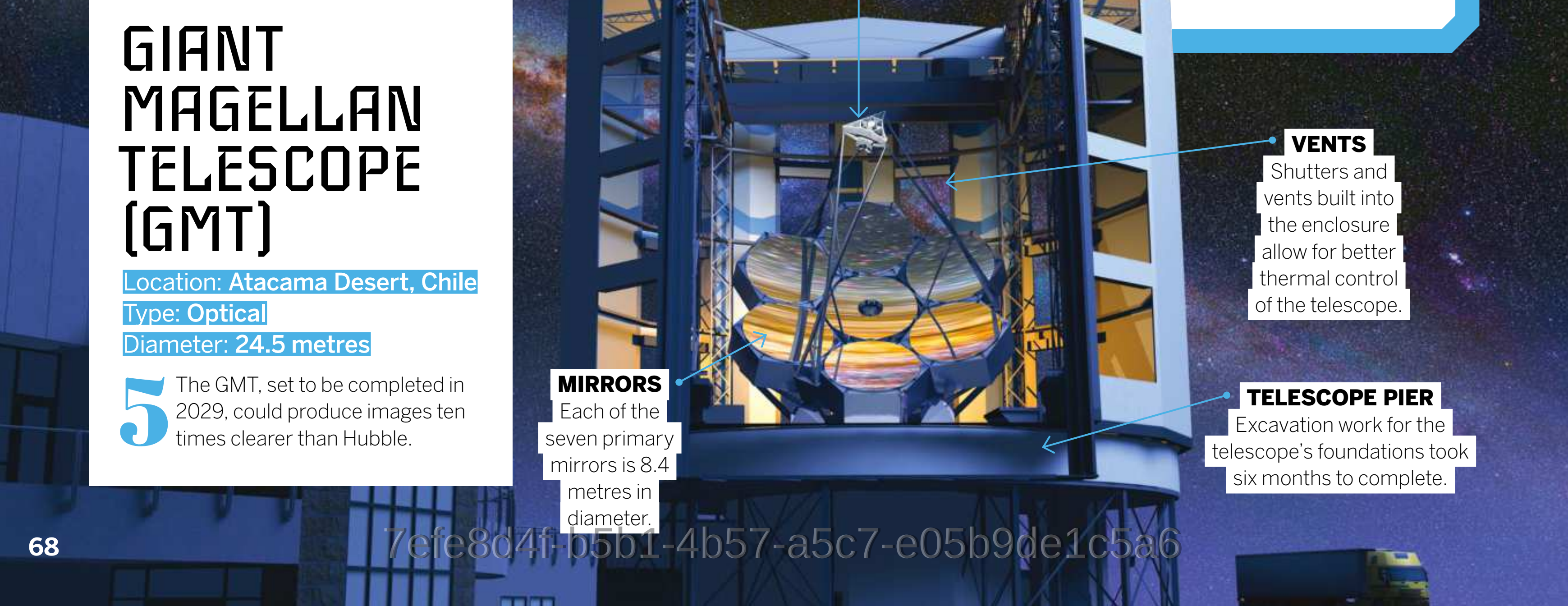
Its name gives away the measurement of the large primary mirror, which will consist of 492 hexagonal panels. Between each 1.44-metre tessellated mirror is a gap of just 2.5 millimetres. The site of this telescope is at an altitude of 4,012 metres, and it will be used to analyse black holes at the heart of the Milky Way and other galaxies.

This illustration shows what the TMT design may look like when complete

GIANT MAGELLAN TELESCOPE (GMT)

Location: **Atacama Desert, Chile**
Type: **Optical**
Diameter: **24.5 metres**

5 The GMT, set to be completed in 2029, could produce images ten times clearer than Hubble.



ENCLOSURE
The two panels either side of the telescope can slide shut to form a protective enclosure.

CALIBRATION SOURCE
This component creates a clear image by removing the interference of scattered light.

VENTS
Shutters and vents built into the enclosure allow for better thermal control of the telescope.

MIRRORS
Each of the seven primary mirrors is 8.4 metres in diameter.

TELESCOPE PIER
Excavation work for the telescope's foundations took six months to complete.

DID YOU KNOW? Puerto Rico's 305-metre-wide Arecibo Observatory collapsed in 2020

SQUARE KILOMETRE ARRAY (SKA)

Location: **Australia and South Africa** Type: **Phased array, radio**
Diameter: **512 by 15 metres**

3 Although the individual size of each of these telescopes isn't as grand as some of the previous entries, the anticipated scale of this construction is much greater. Chosen for their extremely remote locations, the Karoo region of South Africa and the Shire of Murchison of Western Australia are due to host massive radio telescope arrays. In Australia, which is planned to be home to the largest of these sites initially, there will be 512 telescope stations, while 200 will be situated in South Africa.

Scientists estimate that the result of this project will be telescope arrays that are 100 times more sensitive than today's top sites and a sky-surveying time that's around a million times faster. The targeted completion date is 2028 and the arrays are expected to be used for around five decades.

The SKA project is an international effort

EXTREMELY LARGE TELESCOPE (ELT)

Location: **Atacama Desert, Chile**
Type: **Optical-infrared**
Diameter: **39.3 metres**

2 Designed by the European Southern Observatory (ESO), the Extremely Large Telescope, which is due to be completed in 2027, also has extremely lofty goals. These include discovering Earth-like planets and searching for life beyond the Solar System.

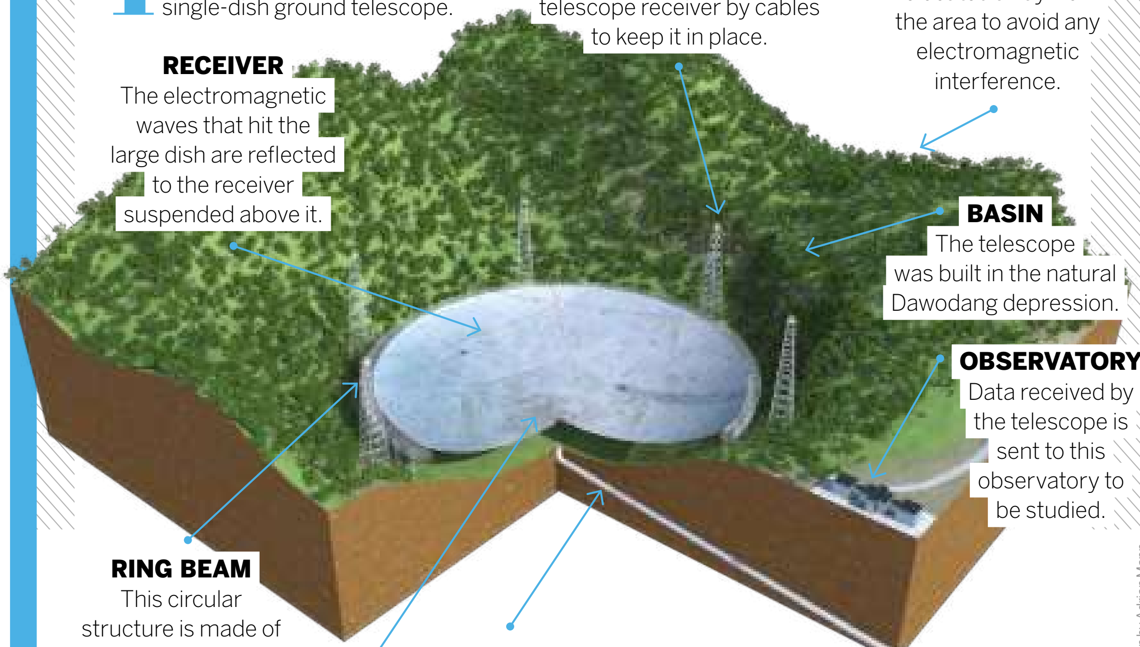
Due to its significant mirror surface area of 978 square metres, the ELT will be able to collect 100,000,000 times more light than a human eye. The telescope will be encased in a huge 80-metre-tall rotating dome that will weigh approximately 6,000 tonnes. The strong foundations for this telescope were completed at the beginning of 2022.

The name was changed from European Extremely Large Telescope in 2017

FIVE-HUNDRED-METER APERTURE SPHERICAL TELESCOPE

Location: **Guizhou, China** Type: **Radio** Diameter: **500 metres**

1 FAST opened in 2020 and is currently the world's largest single-dish ground telescope.



SUPPORT TOWERS
Six towers are attached to the telescope receiver by cables to keep it in place.

REMOTE LAND
More than 9,000 residents were relocated away from the area to avoid any electromagnetic interference.

RECEIVER
The electromagnetic waves that hit the large dish are reflected to the receiver suspended above it.

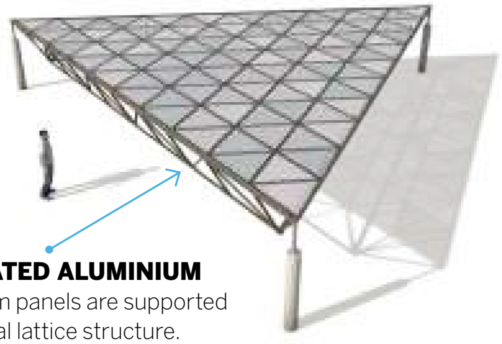
BASIN
The telescope was built in the natural Dawodang depression.

OBSERVATORY
Data received by the telescope is sent to this observatory to be studied.

RING BEAM
This circular structure is made of steel and built into the foundations as the telescope's main support structure.

DRAINAGE TUNNEL
A 1,121-metre tunnel carries rainwater away from the telescope to avoid water damage.

REFLECTOR PANELS
4,450 triangular reflector panels are connected to make up the large dish.



PERFORATED ALUMINIUM
The aluminium panels are supported by a metal lattice structure.

Did you know?
The TMT will be 200 times more sensitive than other telescopes

© Alamy / Getty / TMT Observatory Corporation / Illustration by Adrian Mann

SOLID ROCKET BOOSTER CHEMISTRY

Much of the power of NASA's new rocket comes not from its main engines, but its boosters

WORDS **ANDREW MAY**

The Space Shuttle used solid rocket boosters similar to those on the SLS

Often referred to as the 'mega Moon rocket', the Space Launch System (SLS) is the most powerful rocket NASA has ever built. In addition to the gigantic core stage, two solid rocket boosters (SRBs) operate in parallel with the main engines for the first two minutes of flight, providing the enormous thrust needed to send the rocket on its way to the Moon.

The rocket engines used in space launch vehicles can be divided into two main categories, depending on whether they use solid or liquid fuel. Liquid-fuelled rockets require a separate oxidiser, which is pumped into a combustion chamber along with the fuel to allow burning to occur. In a solid rocket, on the other hand, the fuel and oxidiser can be mixed together and stored in solid form because they won't burn at ordinary temperatures – only when they're heated up by an igniter.

The fact that solid rockets can be stored with their fuel already inside makes them particularly attractive for military applications, and their first use was in missiles rather than space launchers. By the early 1960s, long-range missiles such as Polaris and Minuteman – the latter so named because it could be launched at just a minute's notice – used purely solid propellants. Even so, liquid fuels have their advantages too, notably that they can be throttled up or down, or even switched off and restarted during flight. For this reason many space launchers, such as NASA's Space Shuttle, have employed a combination of solid and liquid rockets for maximum efficiency.

The Space Shuttle used a pair of SRBs, each consisting of four segments, filled with solid propellant. The SRBs used by the SLS are similar in basic design, with a couple of important differences. The first is the addition of a fifth rocket segment, which increases the produced thrust by around 20 per cent. Secondly, unlike those on the Space Shuttle, the SLS boosters aren't meant to be recovered and reused, and removing the systems associated with those activities makes for a simpler and more efficient design. The end result is the most powerful solid-propellant rocket ever constructed.

Did you know?

SRB fuel has the consistency of a pencil eraser

> "They can be stored with their fuel already inside"

HOW SRBS WORK

Fuel and oxidiser are moulded into a single solid cylinder, with a hole running through it acting as the combustion chamber. Once the mixture is ignited, combustion produces superhot gas, which is forced out through an exhaust nozzle that accelerates it to high speed. Thanks to conservation of momentum, the stream of gas creates a thrust that pushes the rocket body forwards. The most common type of solid rocket fuel is aluminium, which burns at a temperature of 3,800 degrees Celsius and releases large amounts of energy in the process.

A ground-based test of one of the Space Launch System's SRBs

MOON ROCKETS

PROTON-K (USSR)

LIFT CAPACITY: 5,375 kilograms (Zond 5)

SATURN V (US)

LIFT CAPACITY: 43,901 kilograms (Apollo 11)

PSLV-XL (INDIA)

LIFT CAPACITY: 1,380 kilograms (Chandrayaan-1)

LONG MARCH 5 (CHINA)

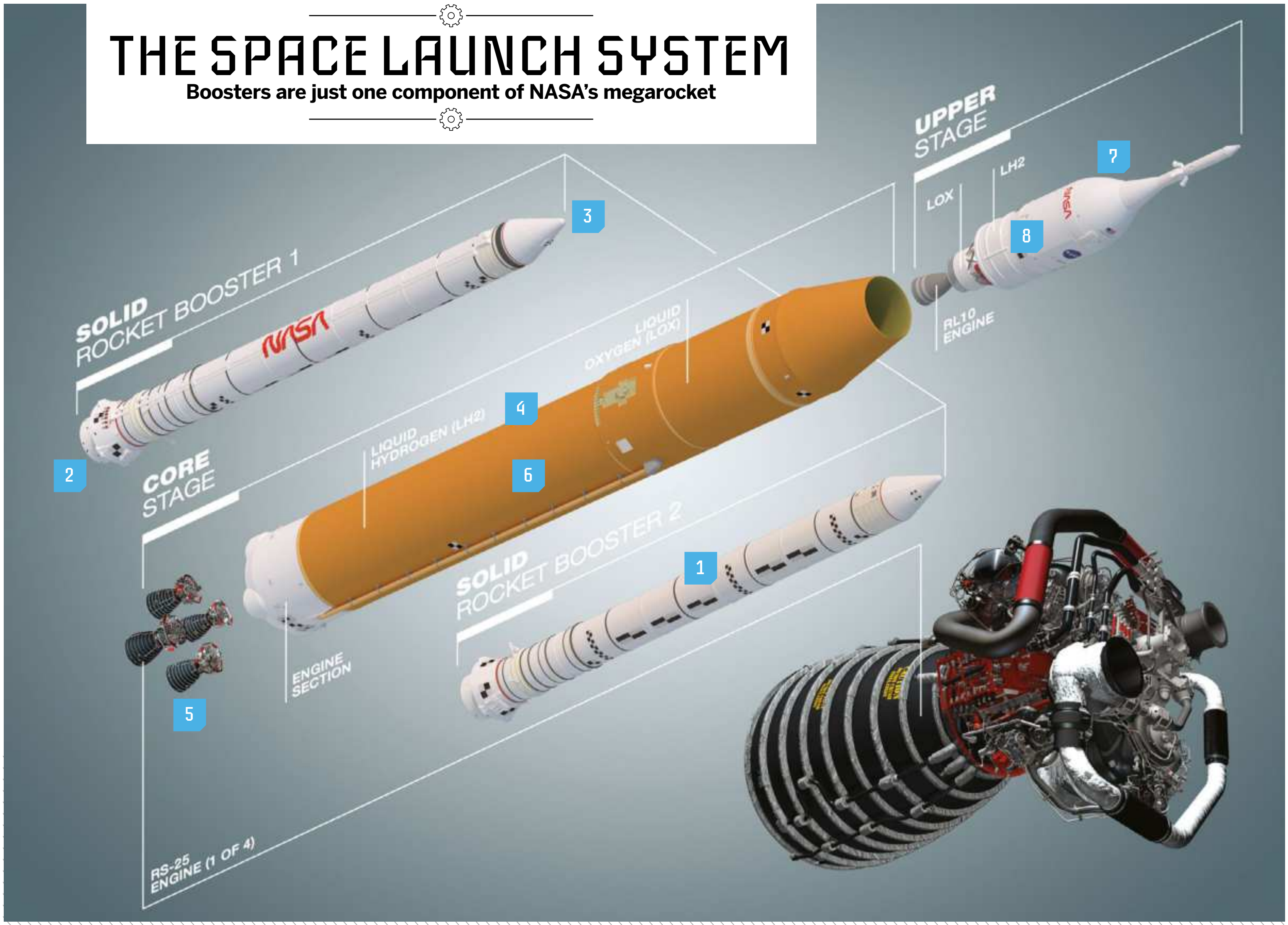
LIFT CAPACITY: 8,200 kilograms (Chang'e 5)

SLS (US)

LIFT CAPACITY: 33,446 kilograms (Artemis 1)

THE SPACE LAUNCH SYSTEM

Boosters are just one component of NASA's megarocket



1 SRB There are two of these, made up of five cylindrical segments containing the solid fuel and oxidiser.

2 SRB ROCKET NOZZLE Designed to maximise thrust, the exhaust nozzle can be steered to control the direction of thrust.

3 SRB IGNITION MOTOR Located at the top of the booster stack, this burns for less than a second to ignite the solid propellant.

4 ATTACHMENT TO CORE STAGE Each SRB is mated to the core stage by braces at the top and bottom of the booster.

5 MAIN ENGINES The four RS-25 engines of the core stage are upgraded versions of the Space Shuttle main engines.

6 CORE STAGE The lower part of this huge rocket stage contains the liquid hydrogen tank, while the upper part contains liquid oxygen.

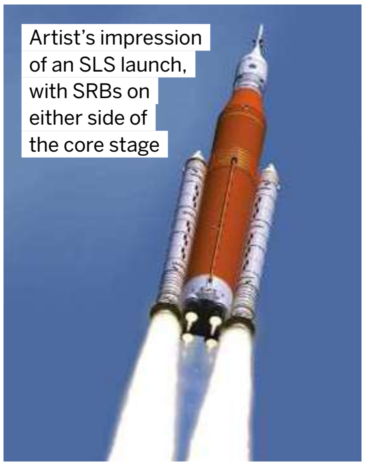
7 UPPER STAGE This has two functions: to boost Orion into a stable orbit and then send it onto the Moon.

8 ORION SPACECRAFT Capable of taking a human crew to the Moon and back, this is the SLS payload on the Artemis missions.

THE ARTEMIS ROCKET

The SLS is designed primarily for one role: to send humans back to the Moon under NASA's Artemis program. The first uncrewed test flight, Artemis I, was originally scheduled for launch on 29 August 2022, but was cancelled during countdown due to technical problems, with further problems causing another cancellation five days later. These problems were related not to the solid rocket boosters, but to the liquid-fuelled core stage. Its fuel is only added on launch day, in a delicate operation involving highly flammable hydrogen at supercold temperatures. With a brand-new rocket and safety being paramount, the delays were frustrating but not unexpected.

The Artemis I rocket on the launchpad at Cape Canaveral


Artist's impression of an SLS launch, with SRBs on either side of the core stage

© NASA / Indian Space Research Organisation / Xiaojun Wang, China Academy of Launch Vehicle Technology

STEAM DECK TEARDOWN

This new portable console takes gaming to the next level

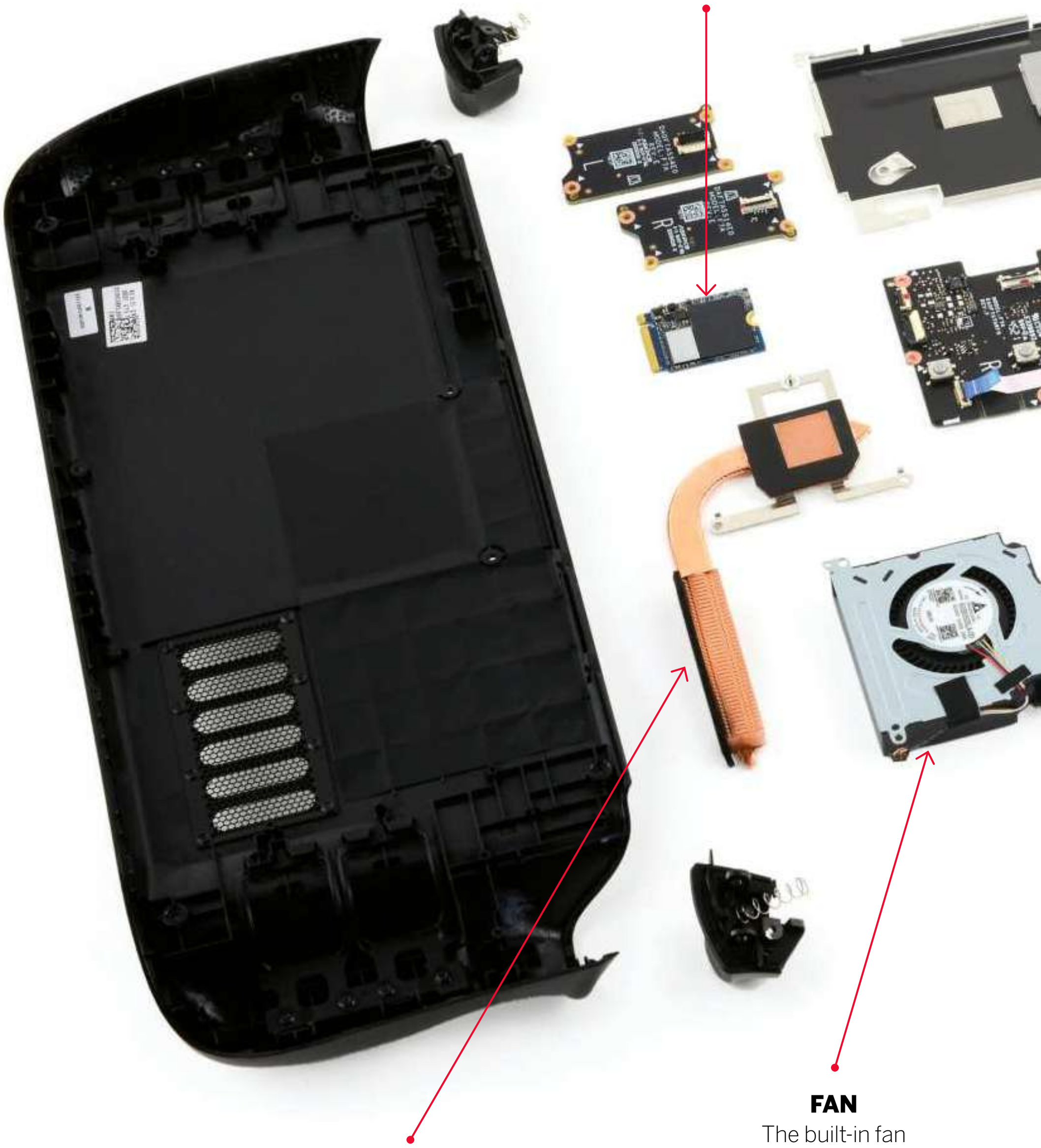
WORDS **AILSA HARVEY**

Games can be streamed from your PC

Released in February 2022 by the video game company Valve Corporation, the Steam Deck is a handheld game console designed with a powerful graphics processing unit (GPU) compared to similar portable consoles. It also includes a large storage capacity so you can download your favourite games. The Steam Deck is available with three storage options: 64GB, 256GB and 512GB, with the latter model featuring an anti-glare screen. For gamers, the comfort and feel of holding a portable device is essential. The Steam, Deck is a relatively large handheld, measuring 30 by 12 by 5 centimetres, making it better suited for adult gamers.

Thousands of games can be played on the Steam Deck, streamed or downloaded from Steam's digital gaming platform. Steam is owned by Valve and was launched in 2003 as a digital distribution site where PC gamers can buy, share and build up a digital library of PC-compatible games. Because the games available for this platform aren't exclusive to the Steam Deck, not all Steam games can be played using a joypad. This makes the touchscreen feature of the Steam Deck console extremely useful. The Steam Deck's style and versatile functionality make it a hybrid of portable games console and PC. It can also be connected to PC monitors or a modern television for a big-screen experience and hooked up to a keyboard and mouse via Bluetooth.

The Steam Deck has a grip cover with handles for comfort



SOLID STATE DRIVE
This storage device holds the SteamOS and game data.

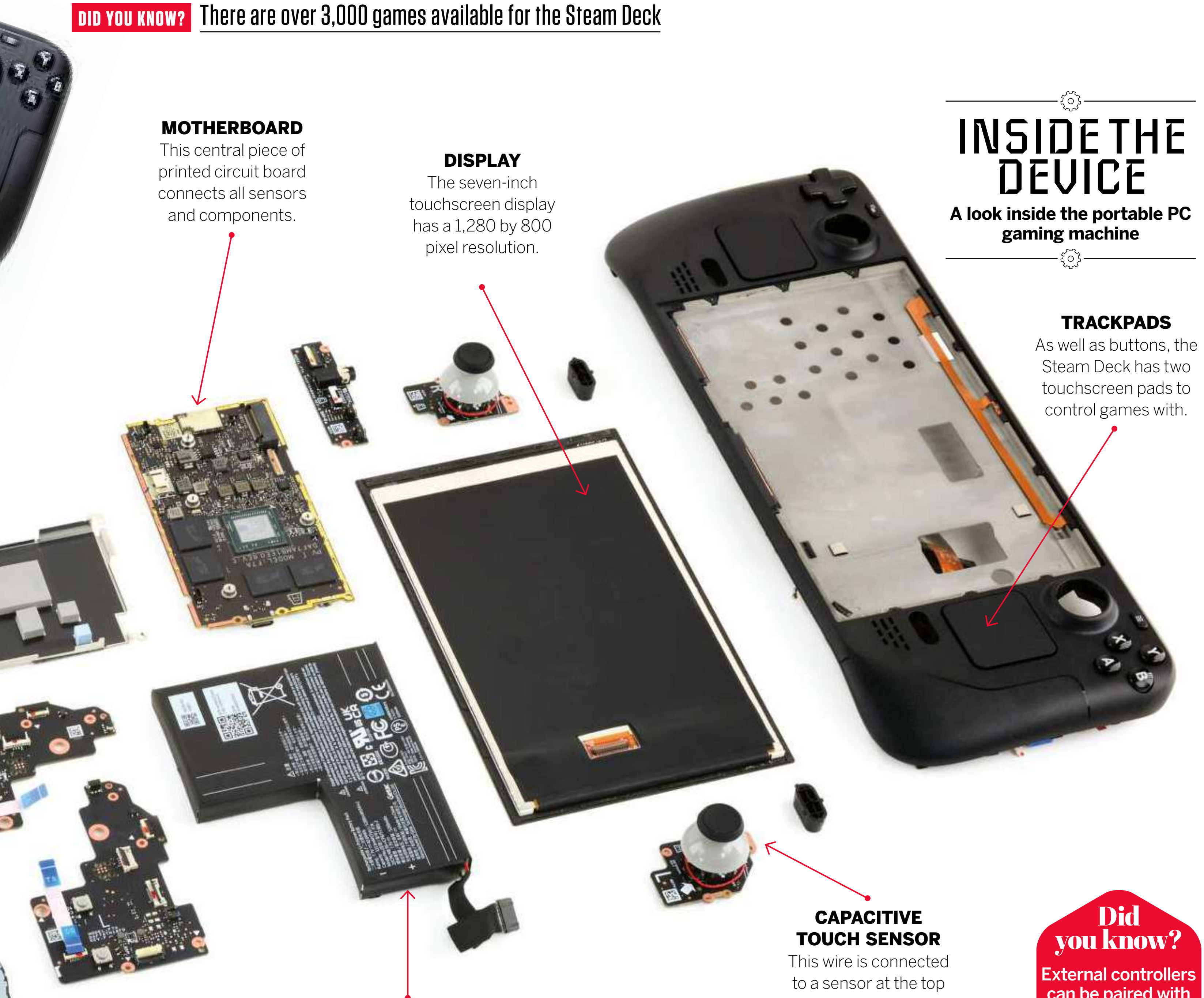
HEAT PIPE
The single heat pipe conducts heat away from the motherboard's central processing unit (CPU).

FAN
The built-in fan cools the console to stop components overheating.

DID YOU KNOW? There are over 3,000 games available for the Steam Deck

INSIDE THE DEVICE

A look inside the portable PC gaming machine



MOTHERBOARD
This central piece of printed circuit board connects all sensors and components.

DISPLAY
The seven-inch touchscreen display has a 1,280 by 800 pixel resolution.

TRACKPADS
As well as buttons, the Steam Deck has two touchscreen pads to control games with.

BATTERY
The two-cell battery lasts for around 90 minutes before it needs to be recharged.

CAPACITIVE TOUCH SENSOR
This wire is connected to a sensor at the top of the thumbstick that detects when a player's thumb is resting on it.

Did you know?
External controllers can be paired with Bluetooth

TRACKPAD GAMING

Being similar in design and portability, the Steam Deck is often compared to the Nintendo Switch. The Steam Deck is wider and heavier than the standard Nintendo Switch, but the Steam Deck is also equipped with two small trackpads that its rival is missing. The Steam Deck's buttons are near the top of the device, allowing room for the trackpads below. These are used instead of – or as well as – the thumbsticks to navigate and control a game. As they are placed where the thumbs naturally rest on the device, it could be inferred that these controllers are the preferred option. In theory, the sensors on the trackpad are better for more precise movements and accurate aiming while playing certain games.

The trackpads take up a significant portion of the control area

© Getty / iFixit / Steam Deck

Incubators help premature babies who are not yet able to properly regulate their own temperature

It was President Kennedy who stepped up efforts to roll out neonatal care following the death of his newborn son

> "Incubators also protect babies from germs and allergens"

HOW NEWBORN INCUBATORS WORK

Found in hospitals around the world, these medical boxes have saved the lives of countless sick and premature babies

WORDS **MARK SMITH**

Incubators are a true medical marvel that have saved the lives of countless babies, so it's hard to believe that the technology can trace its roots all the way back to a French zoo by way of a Brooklyn fairground. Designed to provide a safe and controlled environment for young babies who need a little bit of extra help to grow, develop and get well, an incubator's environment can be adjusted to provide the ideal temperature for a baby, as well as provide the correct amount of oxygen, light and humidity that the doctor thinks the little one needs.

It was Dr Étienne Stéphane Tarnier, a French obstetrician, who saw how well warming chambers worked on baby chickens at Paris Zoo and decided to have special chambers built for babies too. And the rest, as they say, is history. Looking like a clear plastic box, incubators also protect babies from germs and allergens that might harm them while they're in their most vulnerable state. They can also include equipment to track vital signs such as heart rate and temperature.

From egg incubator to human incubator, they're pretty similar in concept, but the ones in hospitals fall into three distinct categories. An open incubator – also called a radiant warmer – has a heating element positioned above or below. As the name suggests, it provides warmth to the baby, but because it's open to the air it doesn't provide protection from germs and allergens. They're used for babies who don't need lots of care.

Closed incubators are essentially a bubble. They surround the baby on all sides, with only portholes in the sides to allow intravenous drips and other medical gear to be put through. They're designed to keep germs and light out. Transport incubators are used to move babies who are unwell. They're much smaller and usually include a mini ventilator, a heart and lung monitor and other medical devices for short-distance trips.

Did you know?

Around 60,000 babies are born prematurely in the UK every year

HATCHING A GREAT IDEA

It was Tarnier who first got the idea for a baby incubator after seeing similar devices used in the zoo to help hatch baby chicks. But a lot of doctors back then weren't too sold on the device's effectiveness. It was another doctor called Pierre-Constant Budin who took this early work to the next level. He began conducting successful research and in 1896 decided to display a prototype incubator at the Berlin World Fair. He even borrowed some premature babies from a Berlin hospital for the exhibit, and people gathered in amazement. Martin Couney, a German doctor, saw the display and realised that if hospitals wouldn't pay for them, he could fund them as attractions at fairs. Crowds would pay to see babies in incubators, which in turn would keep them running. He toured America and even took the exhibition to the famous Coney Island in New York. By the 1940s hospitals began to use them.

Coney Island, the famous seaside resort, was where incubators made their name

DID YOU KNOW? Martin Couney saved the lives of 6,500 babies over the course of his career

HOW DOES AN INCUBATOR WORK?

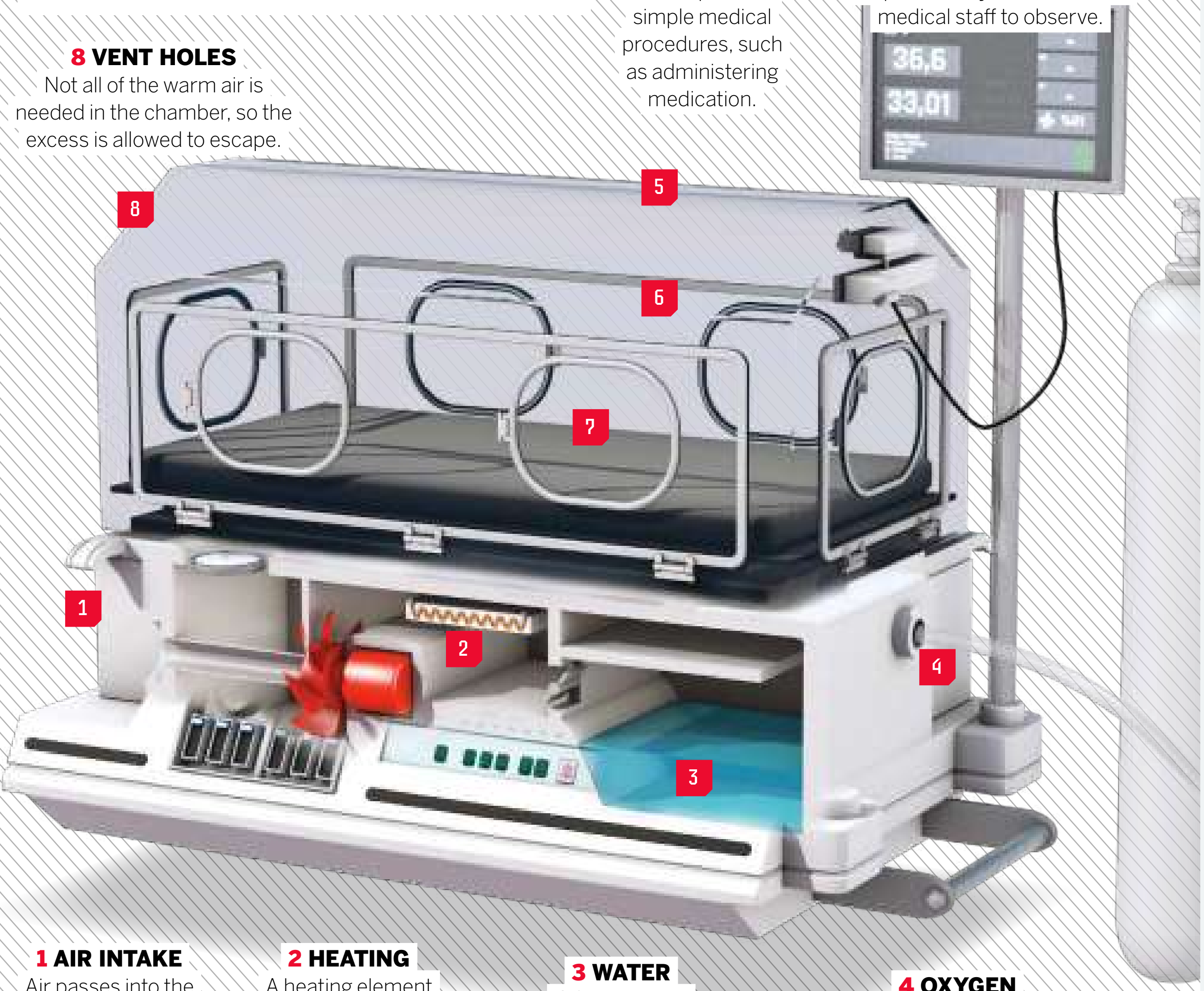
The tried-and-trusted design helps poorly babies get better and grow

6 INSIDE THE INCUBATOR
The moistened and heated air flows into the cabinet with the baby inside to help maintain their temperature.

7 PORTS
The access ports allow medical staff to perform simple medical procedures, such as administering medication.

5 PERSPEX CANOPY
The construction of the incubator keeps the baby safe but allows medical staff to observe.

8 VENT HOLES
Not all of the warm air is needed in the chamber, so the excess is allowed to escape.



1 AIR INTAKE
Air passes into the incubator from outside so it can then be warmed up.

2 HEATING
A heating element gently warms the fresh air for its journey through the incubator.

3 WATER CONTAINER
Water adds moisture to the heated air before it enters the main chamber.

4 OXYGEN
Vital oxygen is added to the warm and moistened air so it's ready to help the infant.

5 FACTS ABOUT INCUBATORS

1 TRANSPARENCY ISSUES
Incubators weren't made of transparent material until the 1940s. This made seeing and treating the babies inside a challenge.

2 PRESIDENTIAL ADVOCATE
US President John Kennedy's newborn son died after being born premature in 1963, which eventually prompted neonatal intensive care units to be set up nationwide.

3 IMPROVING SURVIVAL RATES
Just 30 years ago, fewer than 25 per cent of premature babies survived. Now, almost 90 per cent survive thanks to incubators and specialist neonatal intensive care units.

4 SMALL BABY SURVIVAL
The smallest baby to ever survive was Rumaisa Rahman, a twin who was born in 2004 at 26 weeks weighing just 9.2 ounces – about the same as a hamster.

5 COST OF CARE
The cost to care for just one baby in a specialist unit can often exceed £3,000 ($3,350) per day. A prolonged stay can easily top £1 million ($1.12 million).

LIKE AN ARTIFICIAL WOMB

Infants can need incubator care for many reasons, but the most likely is because they've been born before they've reached the age of 37 weeks. When a baby is premature, they cannot easily regulate their own temperature and need a helping hand. To do this, incubators mimic the womb and temperature is regulated. That temperature varies depending on the weight of the baby and the number of days old it is. This is done by the convection of air produced by an electric heater, which keeps the insides nice and cosy. Over a period of years, neonatal incubators have moved from using gas to electrical heating, but the newest ones contain complex microprocessors that help keep temperatures at the desired levels.

Portholes allow access for medical staff

© Getty / Illustration by Adrian Mann

THE UPS AND DOWNS OF AIR TRAFFIC CONTROL

Air traffic controllers are tasked with keeping pilots, planes and passengers safe in increasingly crowded airways – this is how they do it

WORDS **ROBERT LEA**

When the early pioneers of flight first took to the air in rudimentary craft, they couldn't have imagined just how commonplace air travel would eventually become, or how it would become an integral part of our lives. Air travel has made the world a smaller place – figuratively, at least – with global travel now a far less troublesome and time-consuming practice.

Before the COVID-19 pandemic impacted the industry, the International Air Transport Association (IATA) estimated there were around 39 million flights in 2019. Even with a steep drop in air travel in 2020, there were still around 22 million flights in 2021, with an estimated 2.8 billion passengers travelling by air.

This demand for air space requires intense planning to ensure the safety of aircraft. After all, traffic stop signs and traffic lights can't be placed in the sky for pilots. Instead this responsibility falls to air traffic control.

Before 1930, air traffic control consisted of little more than a man holding two flags and instructing pilots when to stop and when to go. But at the turn of the third decade of the 20th century, just three years after the Ford Motor Company produced the first commercial plane – the 12-passenger Ford Trimotor, or the 'Tin Goose' – Cleveland's airport opened the first radio-equipped control room.

This led to all airlines equipping planes with radio navigation equipment and to the introduction of radio beacons across the US that transmitted directional beams pilots could follow to their destinations. After this, rudimentary air traffic control towers began to spring up across the country. As aircraft improved further, international travel became feasible for commercial flights. This advancement meant the language barrier quickly became a concern in the burgeoning field of air traffic control.

Though English was chosen as the language of air traffic control, communication difficulties were further tackled by the establishment of key phrases and word strings to transmit clear information between pilots and air traffic controllers of different countries. This led to the

© Getty

A plane lands on a runway after being guided home by air traffic control

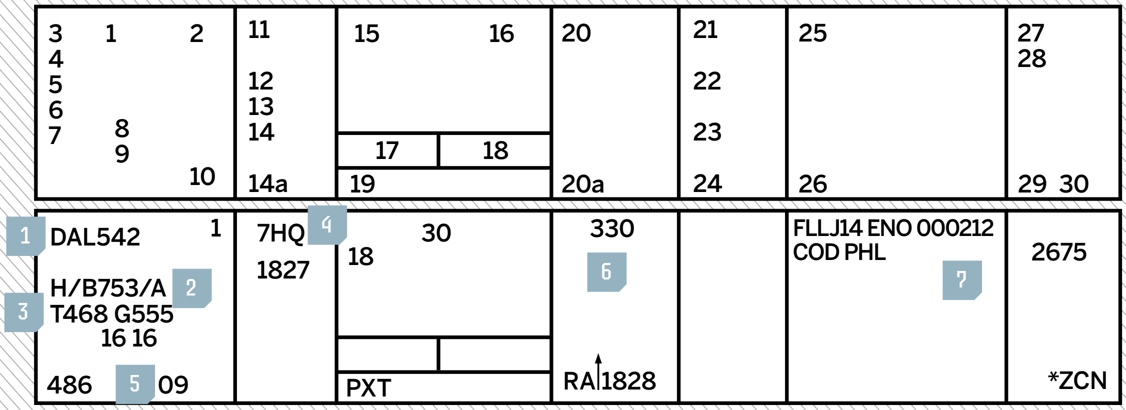
development of a language called radiotelephony – based on English with a lot of technical jargon worked in. As a result, even budding air traffic controllers who are native English speakers need training to speak radiotelephony. By 1950 radar began to replace radio as the key method used in air traffic navigation, utterly revolutionising the field and kick-starting the modern age of air traffic control. It would eventually come to further depend on computers, global positioning systems and other sophisticated equipment to keep people safe in the air.

Despite the common image of air traffic control occurring in air traffic control towers at airports, the real picture is much more complicated. The sky is divided into clearly delineated zones, or flight information regions (FIRs), with different air traffic controllers taking responsibility for these zones. FIRs can be large or small, and a country can have multiple FIRs or just one. FIRs can also be split vertically, with upper regions sometimes labelled upper information regions (UIRs). Of course, air traffic control begins at the airport and with controllers in control towers – a familiar sight to air travellers.

Tower controllers monitor the movement of aircraft and service vehicles from the airport traffic control tower (ATCT). From here the controllers can use an array of equipment and look out large windows that grant a 180-degree or more view of an airfield to keep vehicles separated. From the tower, controllers are responsible for all vehicles, including aircraft, that can be visibly seen. Aircraft further away and not visible to tower air traffic controllers fall under the control of radar operators, who often aren't located in the control tower.

YOUR FLIGHT'S DNA

The flight progress strip contains a wealth of data that will be used throughout a plane's journey



1 CALL SIGN
The aircraft's call sign is a unique identifier used to distinguish it from other aircraft in the area.

2 EQUIPMENT IDENTIFICATION
This code tells air traffic controllers what type of aircraft this plane is.

3 PLANE SPEEDS
The number beginning with 'T' tells controllers the true flight speed of the craft, while the number that starts with 'G' denotes its ground speed.

4 PREVIOUS FIX
This tells air traffic controllers where the aircraft has been previously and the time it was there, with 'fix' being an aviation term for a geographical location.

5 SECTOR NUMBER
This number tells controllers which sector the aircraft is currently flying through.

6 ALTITUDE
This marks the altitude at which the plane is flying in feet. The number has to be multiplied by 100 to give the actual altitude.

7 THE FLIGHT ROUTE
These abbreviations tell controllers where the plane departed from and where its destination is.

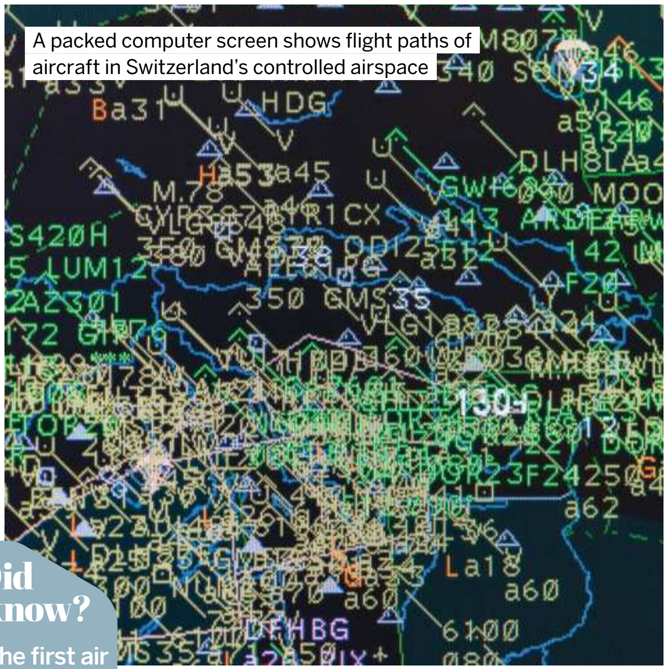
8 THE HANDOFF
In many countries the physical flight progress strip has been replaced by a computer display, meaning 'the handoff' now means the computerised transfer of control of an aircraft from one sector to another.

DID YOU KNOW? Pilots flying over oceans use the Global Positioning System to ascertain their location

In the US, the duty of managing the flow of aircraft to and from an airport falls to approach and departure terminal (ATC) controllers who work in Terminal Radar Approach Control Centers (TRACONs), covering an extended area with a radius between 30 and 50 miles around airports and 3,000 metres above airports. ATCs fall into the rough categories of departure controller, flight data and radar controller and arrival controller.

Farther out, aircraft control is taken over by En route controllers, who can be located at facilities dotted across flight paths and miles away from airports. These controllers use surveillance tech and radar to monitor planes as they move through both continental and oceanic controlled routes through upper airspace. En route controllers work from an en-route centre, or an Air Route Traffic Control Center as they are called in the US. Each centre is responsible for a specific geographic area, handing off to the next region as the plane continues its flight.

As the plane approaches its destination airport, air control is finally handed back to ATC controllers. From here the plane is guided through location sequences to land. This may involve moving aircraft into holding areas up to 1,500 metres above a runway, where craft fly holding patterns until instructed to move to the airport. Controllers are then responsible for 'zipping' aircraft into lines to approach runways, finally falling back under the guidance of ATCT operatives at the destination airport.


A packed computer screen shows flight paths of aircraft in Switzerland's controlled airspace

Did you know?

In 1956, the first air route surveillance radar system was established

Before any of this can happen, however, flight data controllers working in the control tower review weather patterns and enter a flight plan that is filed before takeoff by airlines. This data is turned into a flight progress strip that makes sure each controller in each zone knows the plane's route.

This flight progress strip is handed off from controller to controller as a craft passes through different airway zones and is essentially the 'DNA' of your plane's journey.

5 AIR TRAFFIC CONTROL MYTHS

1 PING PONG BATS
We've all seen the staff on runaways directing planes with flags, lights or even ping pong bat-like signals. These aren't air traffic controllers, but are called flight marshals.

2 SCREEN BURN
Hollywood has a very distinct image of air traffic controls glued to monitors in darkened rooms getting all their information from computers. In fact, the wide windows found in control towers are vital for visually monitoring the planes.

3 TOWER LIFE
Not all air traffic control staff work in control towers; many are located in facilities miles from airports. Also, the image of small crews of stressed staff is a myth: airways are monitored by hundreds of workers.

4 NEAR MISSES ARE COMMON
Near misses can happen, but the attention such incidents garner on social media makes them seem much more common than they are. Air traffic collision avoidance systems (TCAS) warn pilots well in advance of nearby aircraft, letting them avoid close encounters in the sky.

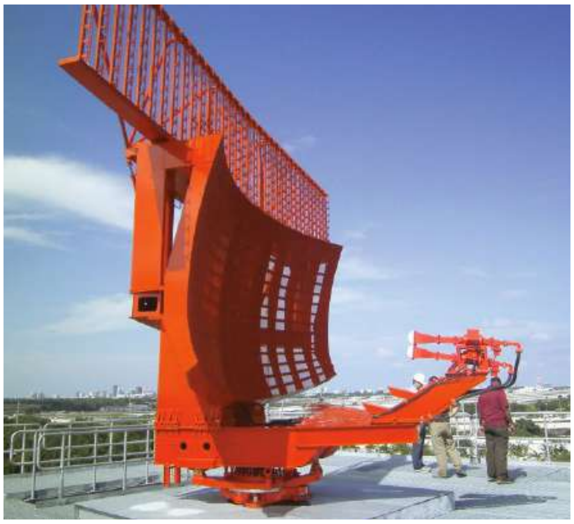
5 SOLE RESPONSIBILITY
A plane's pilot has ultimate responsibility when it comes to landing a plane. Air traffic controllers offer advice, only giving precise instructions when planes pass through weather conditions that severely reduce visibility.

TRACKING FLIGHT PROGRESS WITH RADAR

Air traffic controllers use radar to track the progress of flights. This data can be used to inform any potential course corrections needed to keep aircraft separated or to help pilots avoid adverse weather conditions.

Primary Surveillance Radar (PSR) is a surveillance system that uses ground-based antennae to send radio waves towards aircraft. These are reflected back to the antennae, and the time difference can be used to determine a plane's distance and bearing.

Air traffic control also has another form of radar called Secondary Surveillance Radar (SSR). This allows for the more precise position reporting of aircraft by identifying specific craft's transponders. Because it relies on land-based antennae, radar switches to other location-tracking methods over oceans.


The ASR-9 is a typical air traffic control radar with both PSR (bottom) and SSR (top) antennae

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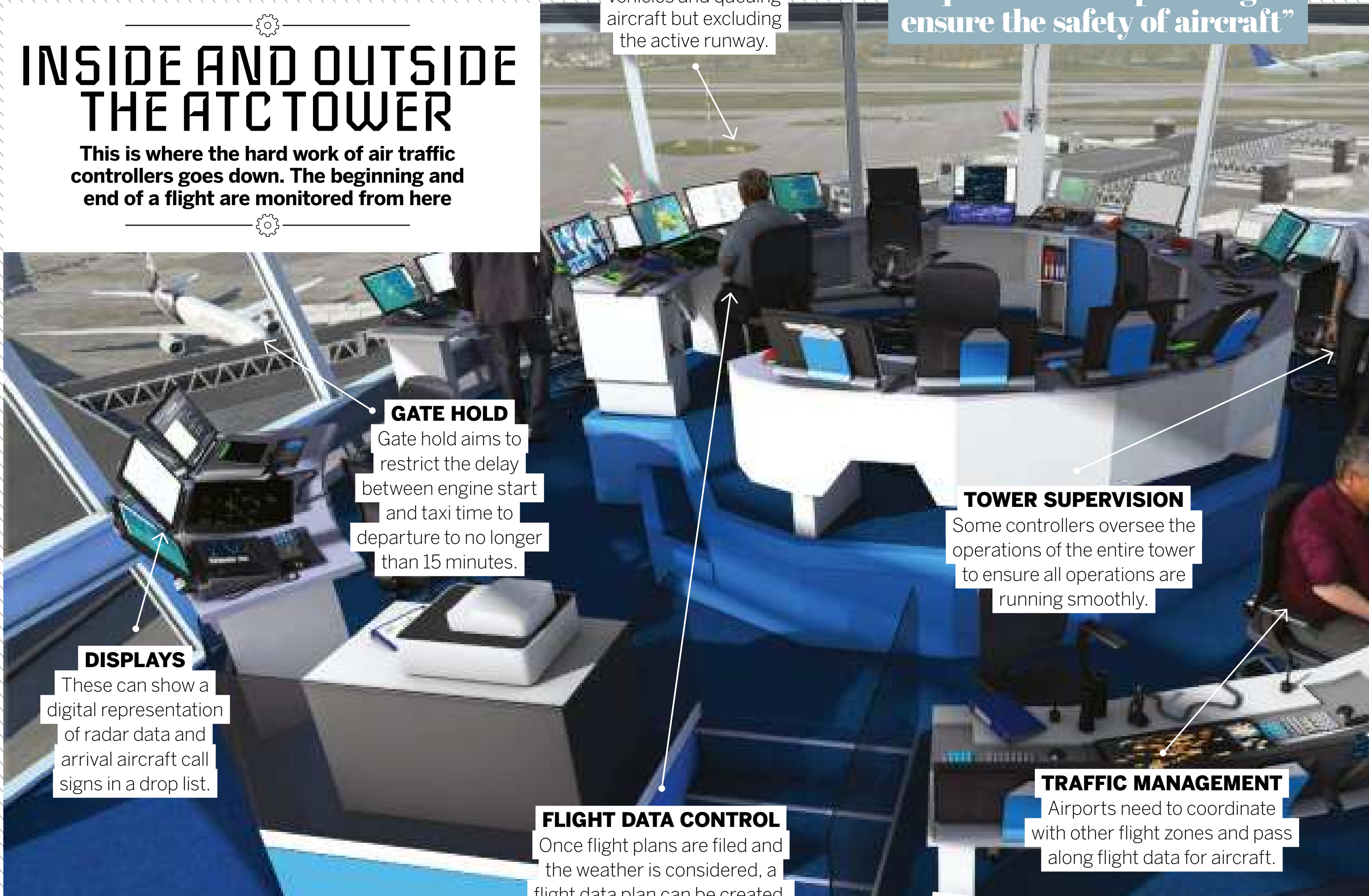
INSIDE AND OUTSIDE THE ATC TOWER

This is where the hard work of air traffic controllers goes down. The beginning and end of a flight are monitored from here



GROUND CONTROL
The movement area of an airfield can be monitored here, including all ground vehicles and queuing aircraft but excluding the active runway.

GATE HOLD
Gate hold aims to restrict the delay between engine start and taxi time to departure to no longer than 15 minutes.

DISPLAYS
These can show a digital representation of radar data and arrival aircraft call signs in a drop list.

TOWER SUPERVISION
Some controllers oversee the operations of the entire tower to ensure all operations are running smoothly.

FLIGHT DATA CONTROL
Once flight plans are filed and the weather is considered, a flight data plan can be created.

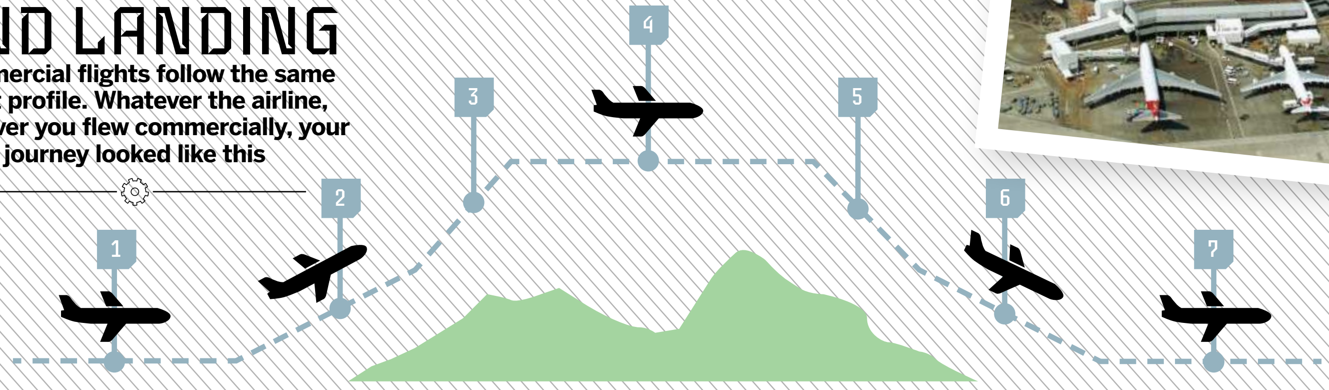
TRAFFIC MANAGEMENT
Airports need to coordinate with other flight zones and pass along flight data for aircraft.

> "This demand for air space requires intense planning to ensure the safety of aircraft"

Planes await the all-clear at Heathrow from ATC tower controllers

TAKING FLIGHT AND LANDING

Commercial flights follow the same flight profile. Whatever the airline, whenever you flew commercially, your journey looked like this



1 PREFLIGHT
The flight begins on the ground with flight checks, push-off from the gate and taxi to the runway.

2 TAKEOFF
The plane is powered up by the pilot and races down the runaway gathering speed.

3 DEPARTURE
The plane lifts off the ground and then climbs to cruising altitude.

4 EN ROUTE
Heading to the destination airport, a plane heads through one or more centre airspaces controlled by air traffic control facilities.

5 DESCENT
The plane is manoeuvred towards the destination airport and begins its descent.

6 APPROACH
The plane is lined up with the landing runway at the destination airport and descends further.

7 LANDING
The aircraft touches down on the destination runway. The plane taxis to its arrival gate at the terminal.

DID YOU KNOW? In airspace with limited air traffic control, military and recreational pilots are responsible for avoiding collisions

A ROOM WITH A VIEW
Large windows allow air traffic controllers in the tower to visually monitor vehicles, including aircraft.

LOCAL CONTROL
Local control watches over the runway and the skies over the airfield. This is where clearance for takeoff comes from.

Did you know?
Transponders are the devices used to identify aircraft via 'squark codes'

ATC EMERGENCY

The UK's Department of Transport lists large passenger aircraft as the safest mode of transport between 2005 and 2015. But emergencies do happen. A pilot experiencing an issue usually begins communication with air traffic control with the word 'mayday', usually repeated three times. This mayday distress call trumps all other communications. In a non-life-threatening urgent situation, 'mayday' is replaced with the word 'pan-pan.'

ATC can use radar and computer systems to place a lock on aircraft in emergencies, denoting them from other craft with the label 'EM', short for 'emergency', so that the plane in distress can be quickly identified. An emergency frequency and even a second controller may be assigned to a plane in distress. Pilots will be asked for the nature of the emergency, the number of people aboard, the volume of fuel the plane is carrying and if rescue and firefighting vehicles are needed. This information helps coordinate an emergency response.

Firefighters and emergency crews await a call for help at Düsseldorf airport

A DAY IN THE LIFE OF AN AIR TRAFFIC CONTROL OFFICER

Air traffic control officer Bart Montilla explains how he keeps you safe in the air

How long have you been in air traffic control and how has it changed?

I got my first job as a tower controller at Bournemouth Airport [England] in 2011. I was then validated as an approach controller in 2014 and worked in both positions until I joined NATS [National Air Traffic Services] in 2019. This is a job that's continuously evolving. As traffic levels increase, new technologies and procedures are introduced to streamline our operations so we can cope with the increased demand and continue providing a safe and efficient service.

While the operation is ever evolving, changes are never introduced too suddenly. Each change, however small, needs to be rigorously safety assessed and tested before being implemented. All personnel are trained in the use of the new equipment or in the new procedures, and normally a trial period is set to ensure the suitability of the change.

The core parts of the job have stayed the same for quite some time, but there have been a multitude of incremental changes along the way.

What's the air traffic tower like as a work environment?

Safety is our absolute number one priority at NATS, and this is what the role is all about – keeping the skies safe. As I'm sure you can imagine, this means that there's a great awareness of all the safety implications of our job and we ensure that we have a robust reporting culture so that any trends can be spotted, training can be provided and that all lessons learned can be shared, creating a very trusting and collaborative workplace.

The first thing most people notice when they enter a visual control room in a tower is the spectacular views from up there. In my case, the first thing I noticed the first time I entered a control centre was how different the atmosphere was to the mental picture I had created in my mind.

I went in there expecting to find people rushing everywhere and shouting instructions across the room. The reality is that everyone is concentrating on their own tasks, speaking in a very calm and relaxed manner. Noises and distractions are kept to an absolute minimum, so there's a surprisingly quiet and focused energy about the room that I was not expecting.

Is it a high-pressure job? How do you 'let off steam'?

Being an air traffic controller can be intense, especially when the skies are busy – for example during the summer months. As is the case for many jobs, there are some moments when total concentration is needed and many others when the workload is lower and you can be a bit more relaxed.

An important part of being an air traffic controller, which may not be a feature in other workplaces, is fatigue management. Staring at a screen and concentrating hard is something that cannot be done for hours on end… it simply wouldn't be safe. Controllers need to take compulsory breaks from duty regularly.

During these breaks we are required to remain outside the operations room and do anything we need to clear our heads – read, watch TV or have a coffee – so we are then refreshed and ready to sit at the radar again.

© Getty / Wiki: Avda Feuerwehr; Bart Montilla

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A: WOOL B: NYLON C: SILK

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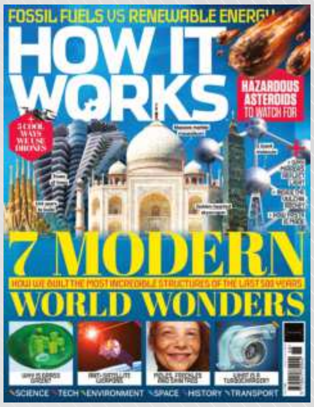
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Are Buzz Aldrin's footprints still on the Moon? If so, why?

Bryn Biggs

We consider the Moon to have no atmosphere. There may be very small traces of some elements, but not enough to constitute an atmosphere. If there's no atmosphere there can be no wind, as there will be no air to move around. With no wind there's nothing to blow the footprints away, so yes, Buzz Aldrin's footprints will still be there on the Moon, as well as any other footprints left by the 11 other astronauts who have been there.

WHY DO WE HAVE A KNEECAP, BUT NOT AN 'ELBOWCAP'?

Cameron James

The kneecap is a sesamoid bone, which means that unlike most bones in the body it grows within the tendons that attach muscles to certain joints. Sesamoid bones form where a tendon passes over a joint, and their purpose is to protect the tendon and to increase its mechanical effect. Human knees are placed under a great amount of stress due to walking upright, and the kneecap is there to help maintain the knee's movement and ability to flex in the correct manner. The elbow doesn't suffer these stresses, as most humans don't walk on our hands. Also, it would seem reasonable that since our knees face forwards – the same direction that we crawl and walk – and our elbows face backwards, the kneecap evolved to protect the knee, whereas the elbow didn't require such protection.

Did you know?

The kneecap is called the patella

CAN YOU HAVE TOO MUCH SLEEP?

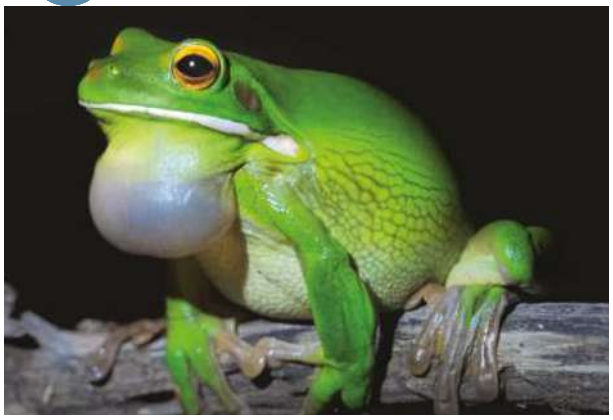
Majid Alsadi

Yes. Oversleeping can cause headaches because you've slept too long without food and water. This is because headaches can be triggered by dehydration and low blood sugar. Depression and other undiagnosed medical problems can cause people to sleep more than average. This may be why studies find that people who sleep more than seven to eight hours have a shorter life expectancy. How much sleep we need varies among individuals and also varies over a lifetime. As babies we need more sleep than when we're older.

WHY DOES A FROG CROAK?

Lily Michel

A male frog can attract a mate by using a mating call. Not only do frogs have vocal cords, like us, but most also have a vocal sac, which is an inflatable membrane that acts like an amp. The frog breathes in, closes its nostrils and forces air back and forth between the lungs and the vocal sac, which vibrates the vocal cords. The air resonating inside the vocal sac amplifies the call.



What's the difference between long and medium wave on a radio?

Alec Gardner

Both of these waves are in the AM radio band. AM radio is the process of broadcasting using amplitude modulation, or changing the height of a wave. The AM band is split into different wavelengths. Long wave has long wavelengths, so the waves are further apart from each other and the frequencies, or number of waves per second, are lower than 532kHz. Medium wave has shorter wavelengths, so the waves are closer together, with frequencies between 532kHz and 1,606kHz.

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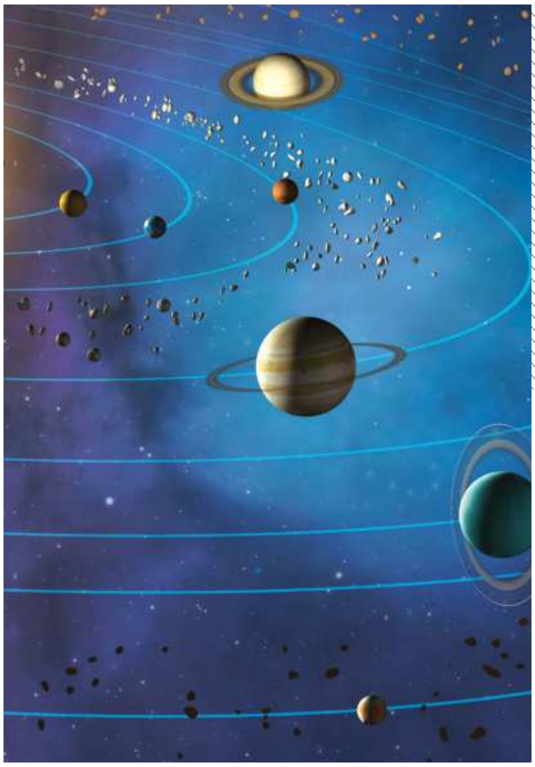
WHY CAN I TASTE EYE DROPS WHEN I USE THEM?

Carol Tooze

There's nothing to worry about; it's perfectly natural. There are small openings in the inner corners of your eyelids that allow the drainage of excess fluid, such as eye drops, into a tube called a tear duct, or nasolacrimal duct. Eye drops are then transported to the back of your nose and throat and can be tasted. This system usually removes excess tears that lubricate and protect our eyes from infection. As a side note, this link between the back of our throat and our eyelids also explains how someone can appear to 'drink' a liquid, such as milk, and shoot it out through their eyelids.



Why does the asteroid belt in our Solar System stay in place?

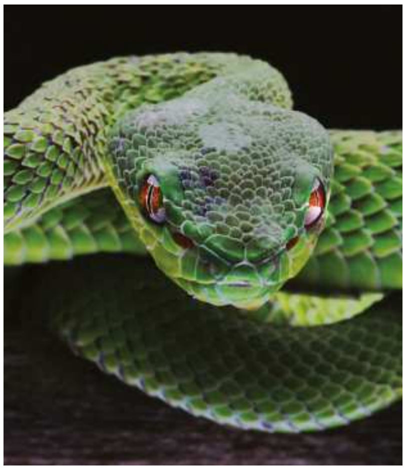
Sam Land

Asteroids are relatively small rocky and metallic objects that orbit the Sun. Many asteroids are found between Mars and Jupiter, called the main asteroid belt, with the popular hypothesis being that its creation came about from leftover matter that never formed a planet in the formation of our Solar System. Gravity keeps the asteroids in orbit around the Sun, but the main asteroid belt we see today is only a tiny fraction of what used to exist and is predominately empty space. The gravitational fields of Mars and Jupiter, as well as collisions within the belt, also have an effect on the orbital paths of asteroids and can lead to their expulsion from the main belt.

WHAT DOES IT MEAN WHEN WE SAY AN ANIMAL IS COLD-BLOODED?

Robert Smith

Generally, cold-blooded animals don't use their own energy to warm themselves and maintain their body temperature. Warm-blooded animals heat themselves with energy from food, so they need to eat more regularly than cold-blooded animals. The only two warm-blooded groups are mammals and birds. Reptiles, amphibians, fish and invertebrates are cold-blooded. Many cold-blooded animals increase and control their temperature by basking in sunlight. Others, especially invertebrates, require their environment to be warm enough before they are able to move quickly. Many cold-blooded animals need to hibernate if they are to survive cold winters.



WHY DO ELEPHANTS HAVE SUCH LONG GESTATION PERIODS?

Thomas Nolan

Long gestation periods are a feature of many larger mammal species. For example, the gestation period of the blue whale is 12 months or more. This extended gestation period allows the newly born animal to be able to function almost independently – apart from requiring its mother's milk – from the very start. However, the length of the gestation period may also be related to the animal's large size. Think of other animal species where the young are born blind and unable to move without the aid of their parents, making them vulnerable to predators.

Why are flamingos pink?

Nick Morgan

Flamingos aren't pink; they are actually white. However, they are able to deposit carotenoid pigments in their skin and feathers. The birds obtain these pigments via their natural food, particularly from algae. Flamingos assimilate the carotenoids into so-called canthaxanthin – a red pigment also used in the food industry, for example, added to sausages – and incorporate that into their plumage. The surplus of red pigment is stored in the liver and will be used during the next moult to colour the new feathers pink. Flamingos that lack carotenoids in their food will turn white after the next moult, as zookeepers in the past have witnessed.

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If our Milky Way travels at 190 miles per second, why don't we feel it?

Mustafa Omar

When travelling in a car at a constant speed, we don't feel the car's forward motion as our bodies are travelling at exactly the same speed as the vehicle. We become aware of the vehicle's movement if it accelerates or decelerates because our bodies are suddenly travelling at a different speed to our surroundings. Though our galaxy is travelling at 190 miles per second, so are we. As the galaxy's speed is not accelerating or decelerating by a noticeable amount, we're not aware of the motion.

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WHAT FOOD DO PLANTS NEED TO SURVIVE? AND WHAT'S IN THE SACHETS WE GET WHEN WE BUY CUT FLOWERS?

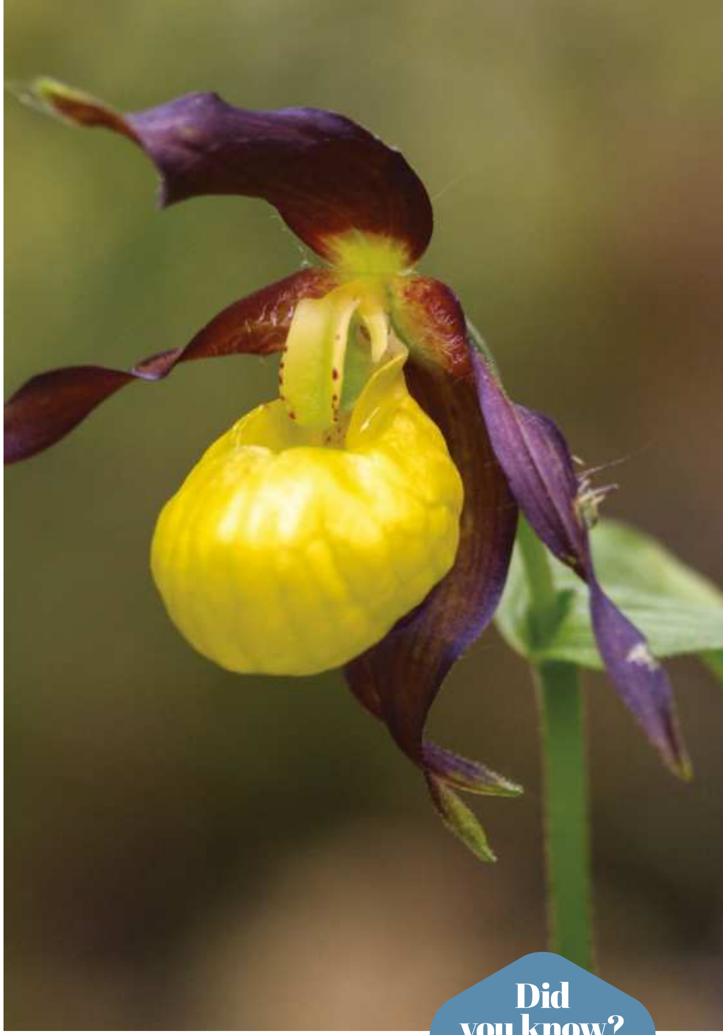
Gareth Sterling

Just like every other form of life, plants need a wide range of elements to build the necessary chemicals to survive and grow. Some they need in very small quantities, whereas the most commonly used tend to be the things that we make available in plant fertilisers – NPK, or nitrogen, phosphorus and potassium. There's also carbon, which is probably the main building block the plant acquires through photosynthesis. Cut flower food sachets contain sugars to provide the plant with food and energy and also something acidic, like citric acid, which helps control the bacteria in the water that causes the flowers to die more rapidly. You can make your own plant food with fizzy lemonade and water; lemon juice, sugar and bleach or vinegar and sugar mixes.

WHAT'S THE MOST UNUSUAL PLANT NATIVE TO THE BRITISH ISLES?

Chelsea Jenkins

Some plants are biologically unusual because they catch animals to supplement their poor diets. These include the beautiful sticky-leaved sundews, or the bladderworts with their little lobster pot-type traps for water fleas. Other strange plants have done away with leaves entirely – in some cases, roots too – and rely on other plants for their nutrients. Perhaps the most unusual native examples of these parasites are the dodders, which look like brightly coloured strands wrapped around the host plant. They puncture its plumbing in lots of places through structures called haustoria and extract the water, nutrients and metabolites. But if by unusual you mean very rare or exotic-looking, the lady's slipper orchid might be a good candidate. It has big, colourful flowers and had become so rare because people dug it up that only one native clump was known to survive.



Did you know?

Killer whales are actually a type of dolphin

WHY DO WHALES HAVE BLOWHOLES?

Karen Legg

Blowholes are equivalent to the nostrils of land mammals. Whales, dolphins and porpoises have blowholes on top of their heads so they can lie at the surface of the sea and breathe easily. Baleen – or filter-feeding – whales have a pair of blowholes, while toothed whales, dolphins and porpoises have a single blowhole.

What is royal jelly?

Sally Flemming

Royal jelly is a milky-white food that is secreted by glands in the throats of worker bees and fed to bee larvae. It's named as such as it was once believed that this was only fed to those larvae in the colony destined to become queens. We now know that this protein-rich food is fed to all bee larvae in the colony, but larvae that are to become workers are fed small amounts and those set to become queens are given an excess of this food.

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The latest book releases for curious minds

MEDICINE: A MAGNIFICENT ILLUSTRATED HISTORY

FROM MUMMIES TO MRI SCANS

AUTHOR **BRIONY HUDSON**
ILLUSTRATOR **NICK TAYLOR**
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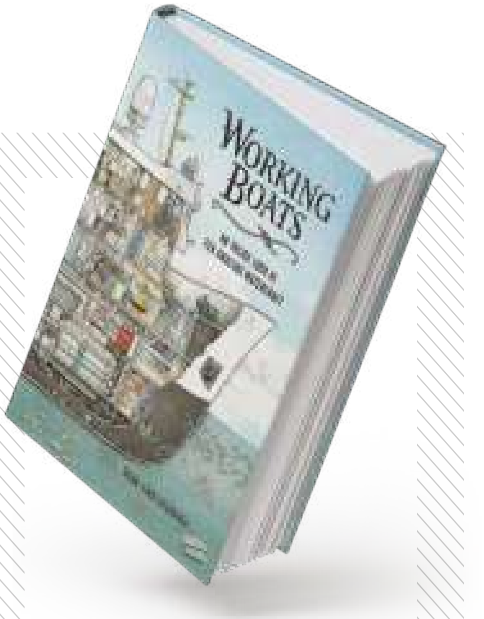
For most of us, 'medicine' simply means a couple of aspirin when we have a headache, a prescription for antibiotics when we have a nasty cough or something a doctor practices. This is all true, although off-the-shelf pharmaceuticals and modern GP techniques are a very small part of the expansive history of medicine. No doubt that for the sake of squeezing everything into an 80-page tome, *Medicine: A Magnificent Illustrated History* has left out entire categories of medical history that have some bearing on the methods used today, but it still feels pretty comprehensive anyway.

Taking us across thousands of years of experimentation, eureka moments and unscrupulous quacks, author Briony Hudson has selected some big milestones in the treatment of disease and injury: the esoteric beliefs of ancient cultures and medieval physicians who categorised human ailments into four different 'humours', how plagues and pandemics were dealt with in the past, the absolutely critical discovery of penicillin, our understanding of mental health, the role 'big pharma' plays in the development of modern medicines, women in medicine, surgical history… the list of chapters goes on, all of them dealt with in a succinct and engaging bedside manner. Nick Taylor's striking colour-block illustrations give this book a suitably vintage-era style, and its overall design gets an appreciative nod from us at **How It Works**. Between the boxes of text and in healthy doses are annotated images, cutaway illustrations and even comic strips. We particularly enjoyed the Burke and Hare comic strip, a dark tale that hails from Edinburgh in the early 19th century that nevertheless has led us to the establishment of proper rules around autopsies and a fuller understanding of human anatomy.

"A succinct and engaging bedside manner"

Despite feeling more adult in tone and being something that parents would enjoy reading, we'd still recommend *Medicine: A Magnificent Illustrated History* to older school-aged children and tweens. It strikes an excellent balance between educating and storytelling that many curious minds would love.



WORKING BOATS

A LOOK INSIDE TEN AMAZING WATERCRAFT

AUTHOR **TOM CRESTODINA**
PUBLISHER **SASQUATCH BOOKS**
PRICE **£16.99 / $19.99**
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From salmon trawlers to floating laboratories, this illustrative book is full of fun facts about the world's working-class boats. Rather than simply detailing the inner mechanics, cabins and rooms aboard a vessel and what they do, each of the ten boats in this book has been cut across the middle to expose what's inside. The level of detail in each illustration is the real champion of *Working Boats*. Each time you examine the ship's cross-section you're guaranteed to notice something different.

There's plenty of extra information about the jobs these boats do, such as how a king crab cage works and how sensors deployed by research vessels map the ocean floor. It even goes into detail about the mechanics of propulsion for different boat types. Suited to a younger audience, this is a fun introduction to nautical engineering that's packed with insight and great illustrations.

BE THE CHANGE – BE CALM

RISE UP AND DON'T LET ANXIETY HOLD YOU BACK

AUTHOR **MARCUS SEDGWICK**
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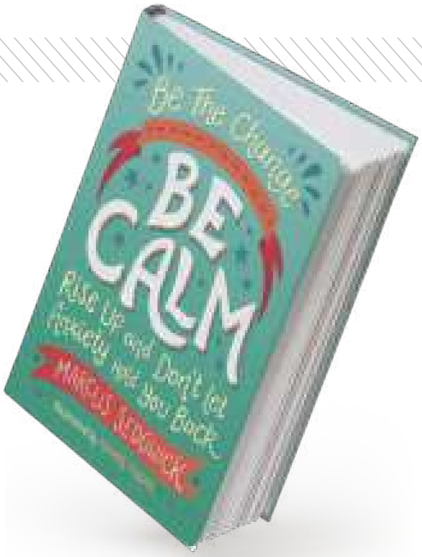


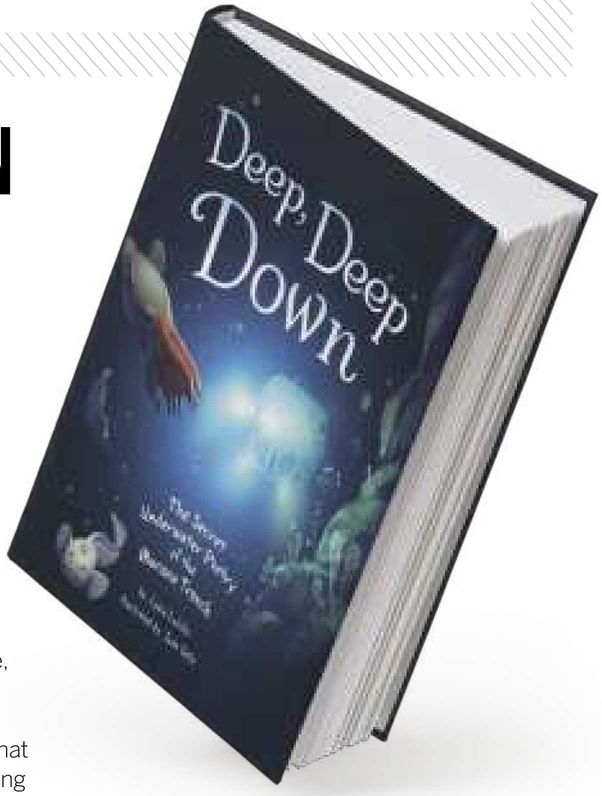
Another book in the Be The Change series, this calming edition explores the world of anxiety and stress. From the concept of catastrophising to learning the ways of a realistic optimist, this book covers the many facets of our human emotions and hands out helpful tips and tricks to get to grips with them.

Along with revealing the theory behind anxiety, *Be Calm* also acts as a guide to give its reader simple ways to shut down anxiety and calm down their mind. There are many activities and tasks that let the reader perform a 'body scan', whereby they address their mental health and how their bodies respond to stress. This is a book that makes you wish you had access to it as a child to better understand how anxiety can affect your life: it's an exceptional tool to help a generation live a happier and calmer existence.

DEEP, DEEP DOWN

THE SECRET UNDERWATER POETRY OF THE MARIANA TRENCH

AUTHOR **LYDIA LUKIDIS**
ILLUSTRATOR **JUAN CALLE VELEZ**
PUBLISHER **CAPSTONE EDITIONS**
PRICE **£17.13 / $18.99**
RELEASE **1 JANUARY**



What swims near the surface is just a tiny fraction of marine life. In *Deep, Deep Down*, the reader jumps aboard a submarine to explore what life looks like in the darkest ocean depths. When the rays of sunlight fade, the creatures that emerge seem more alien. Each double-page illustration captures the remarkable beauty of the distinct life forms that have evolved to survive in areas that are lacking in food, light and warmth.

When new animals are spotted during the journey downwards, small fact boxes provide key information about their sizes, names and depths. With close-up illustrations, readers come face to face with marine life such as the rattail fish, which can spend 200 days with no food, or the deepest swimming of all fish, the snailfish.

Although readers are likely never to see most of the animals described in real life, the text paints a vivid picture with artistic descriptions of movement, behaviour and appearance, making it feel like a true tour. Before returning to the surface, the author allows the reader to dance with the deepest creatures. With no eyes, heads, hearts or lungs, life over 10,000 metres down flows with the water's currents like a unique form of art. For adventurous readers aged between eight and ten, this book is the key to unlocking the secrets of the expansive oceans.

BRIGHT NEW WORLD

THE BOOK FOR A BETTER PLANET

AUTHOR **CINDY FORDE**
ILLUSTRATOR **BETHANY LORD**
PUBLISHER **WELBECK PUBLISHING**
PRICE **£18.99 / $19.95**
RELEASE **OUT NOW**

In *Bright New World*, author Cindy Forde explains how we as a population can work together to regenerate the rainforests, find amazing power alternatives, clean up the seas and change people's mindsets for a fairer world. Each of the technologies shown are based on real-life science taking place today. A handful of forward-thinking scientists from around the world are named and introduced throughout the book for a perfect window into reality. Some of the solutions include solar-powered towers that are intertwined with nature, vertical food farms to eradicate world hunger, jellyfish robots to protect coral reefs, a transcontinental hyperloop ride to school and accessible education for everyone worldwide.

The layout of each section is varied to keep readers engaged, including a 'menu for a healthier planet' to demonstrate the impact of our diets, graphs to explain more complex science and snappy fun fact boxes. There's room for improvement in much of the human lifestyle to create a bright new world, and this book will open more minds to our shared potential.

BRIGHT NEW WORLD

BRAIN GYM

Give your brain a puzzle workout

Sudoku

Complete the grid so that each row, column and 3x3 box contains the numbers 1 to 9

EASY

	2	1			6			
	9	4	8				2	6
6	8	3	5	9	2	7	1	4
			1	4	5	6		
9		5		2	3	8		7
4				8				
			2	6	8		7	
8			3			2		
2			9			1	5	

MEDIUM

		7	5	6				2
	3		1				5	
				9	8			7
				8			2	
8	7				3	4	9	
3		5						6
6	4	9					1	
7		3			5	8		4
	5				1	3	7	

HARD

8				6			1	
9								
2					3		5	
	8	5			2			7
4		3				2		
			9	5		8	4	
		8					3	
1		9	8					
		4		1			2	

Word search

Find the following words

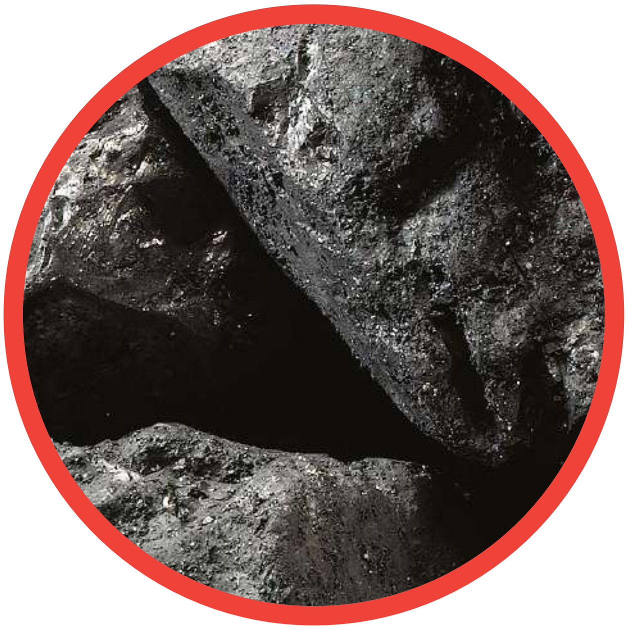
SPIDER
INCUBATOR
ANGEL
DECK
PLASTIC
DOG
MYTH
STARS
CONTROL
NEST
BOG
EYE

S	O	G	E	K	I	N	G	O	P	A	Z	T	D	A
I	P	T	O	C	O	N	T	R	O	L	E	B	O	J
K	U	I	M	K	G	S	R	A	T	Z	I	X	G	E
N	E	V	D	C	K	E	Y	K	O	G	N	H	L	Y
A	M	G	L	E	S	T	A	S	R	O	C	N	E	S
T	I	N	C	D	R	E	Y	W	O	H	U	F	J	O
R	L	A	S	T	A	B	I	C	E	Y	B	O	G	D
D	N	E	S	T	I	P	E	L	D	J	A	P	I	N
E	Q	U	Y	E	O	G	A	C	O	N	T	R	Q	L
K	I	S	M	Y	T	H	O	B	H	G	O	G	E	F
C	O	M	T	B	O	L	P	E	Y	N	R	J	D	M
W	I	T	F	P	L	A	S	T	I	C	M	Y	E	Y
D	O	K	Y	E	N	X	O	L	B	I	J	O	F	T
A	N	G	E	L	I	S	T	E	C	K	I	D	E	P
E	S	V	O	G	E	L	Z	S	R	A	T	S	X	E

What is it?

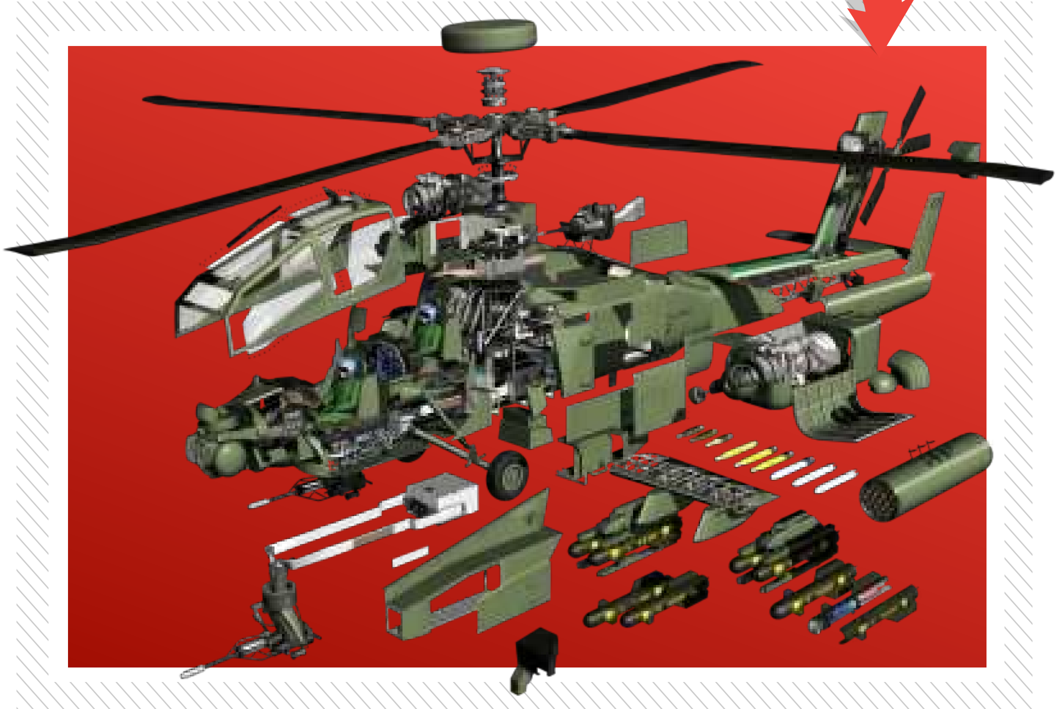
Hint: A dirty form of energy

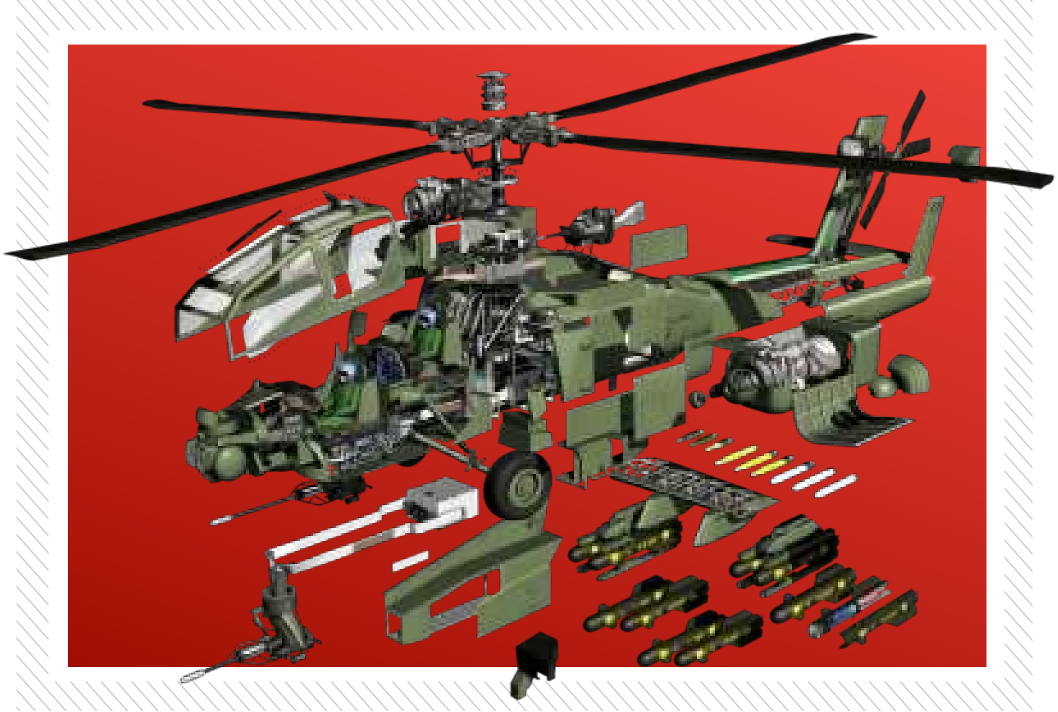
A



Spot the difference

See if you can find all six changes between the images below





QUICKFIRE QUESTIONS

Q1 What is the pH of human stomach acid?

○ 1.0 to 2.0
○ 3.0 to 4.0
○ 8.0 to 9.0
○ 10.0 to 11.0

Q2 Where is most of the world's oxygen produced?

○ Space
○ The ocean
○ Rainforests
○ Earth's core

Q3 What rains down on the planet Saturn?

○ Water
○ Methane
○ Gold
○ Diamonds

Q4 Around what percentage of your body is bacteria?

○ 1 per cent
○ 10 per cent
○ 50 per cent
○ 90 per cent

Q5 How long has the average person spent playing video games by the age of 21?

○ 24 hours
○ 3 weeks
○ 103 days
○ 208 days

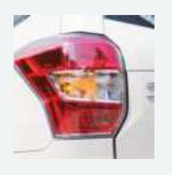
Q6 How much did the original VCR cost in 1956?

○ $10,000
○ $50,000
○ $250,000
○ $1 million

Answers

Find the solutions to last issue's puzzle pages

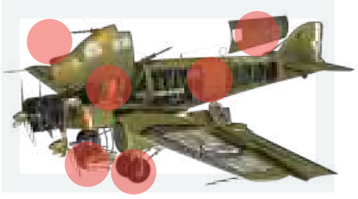
Q1 47 MILES PER HOUR
Q2 A GRAPEFRUIT
Q3 230 LITRES
Q4 HAWAII
Q5 ART
Q6 WATER



What is it?

A CAR'S BRAKE LIGHT

Spot the difference



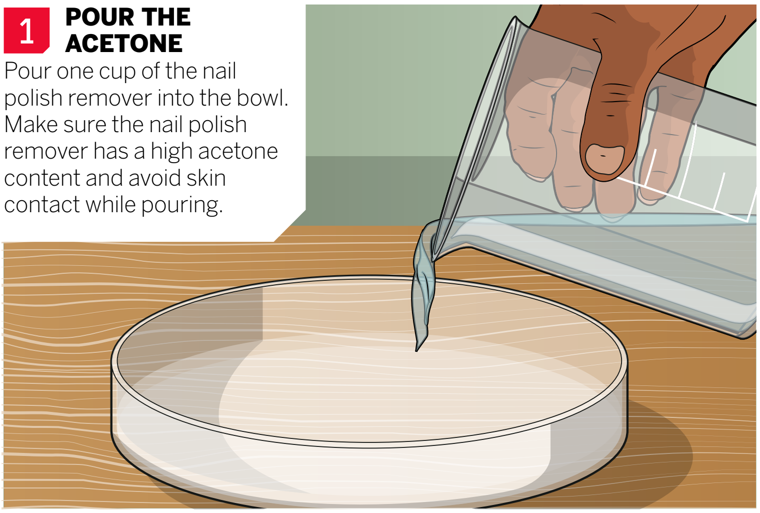
© Getty

MAKE A SPIDER'S WEB

Weave your own web with Styrofoam and nail polish remover

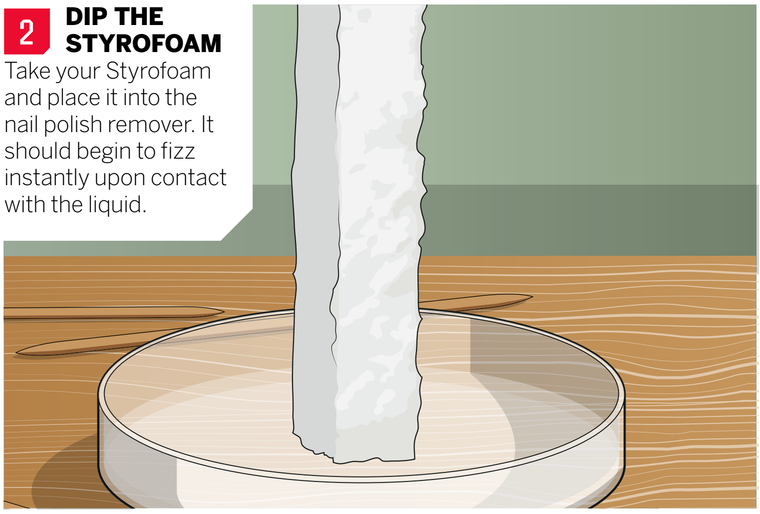
KIT LIST

- Acetone-based nail polish remover
- Styrofoam
- Cocktail sticks
- Bowl
- Syringe
- Sponge



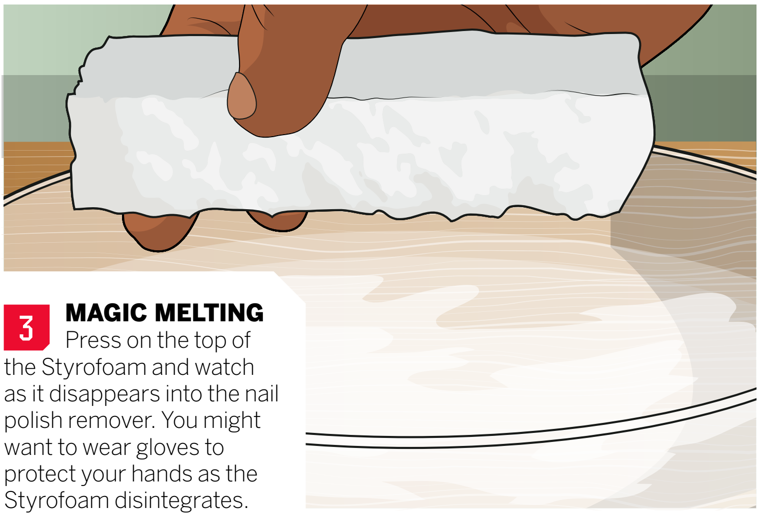
1 POUR THE ACETONE

Pour one cup of the nail polish remover into the bowl. Make sure the nail polish remover has a high acetone content and avoid skin contact while pouring.



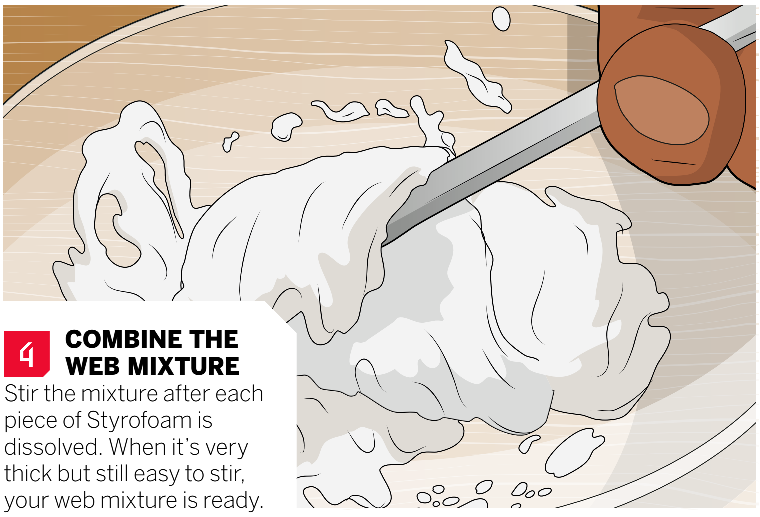
2 DIP THE STYROFOAM

Take your Styrofoam and place it into the nail polish remover. It should begin to fizz instantly upon contact with the liquid.



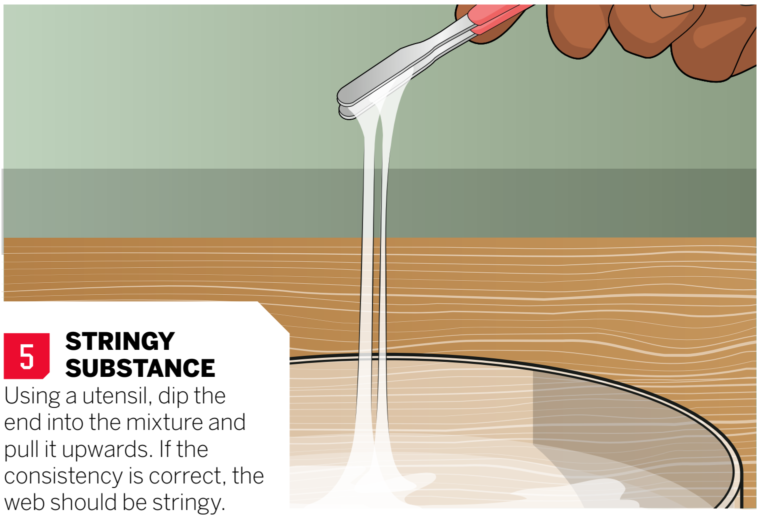
3 MAGIC MELTING

Press on the top of the Styrofoam and watch as it disappears into the nail polish remover. You might want to wear gloves to protect your hands as the Styrofoam disintegrates.



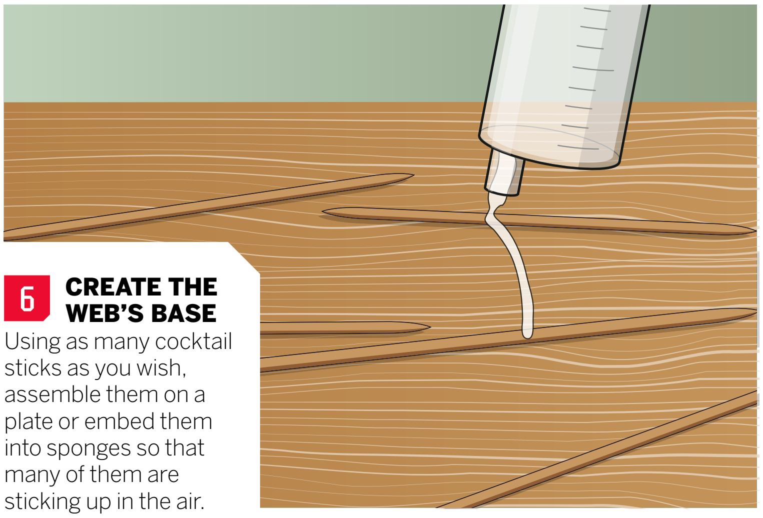
4 COMBINE THE WEB MIXTURE

Stir the mixture after each piece of Styrofoam is dissolved. When it's very thick but still easy to stir, your web mixture is ready.



5 STRINGY SUBSTANCE

Using a utensil, dip the end into the mixture and pull it upwards. If the consistency is correct, the web should be stringy.



6 CREATE THE WEB'S BASE

Using as many cocktail sticks as you wish, assemble them on a plate or embed them into sponges so that many of them are sticking up in the air.

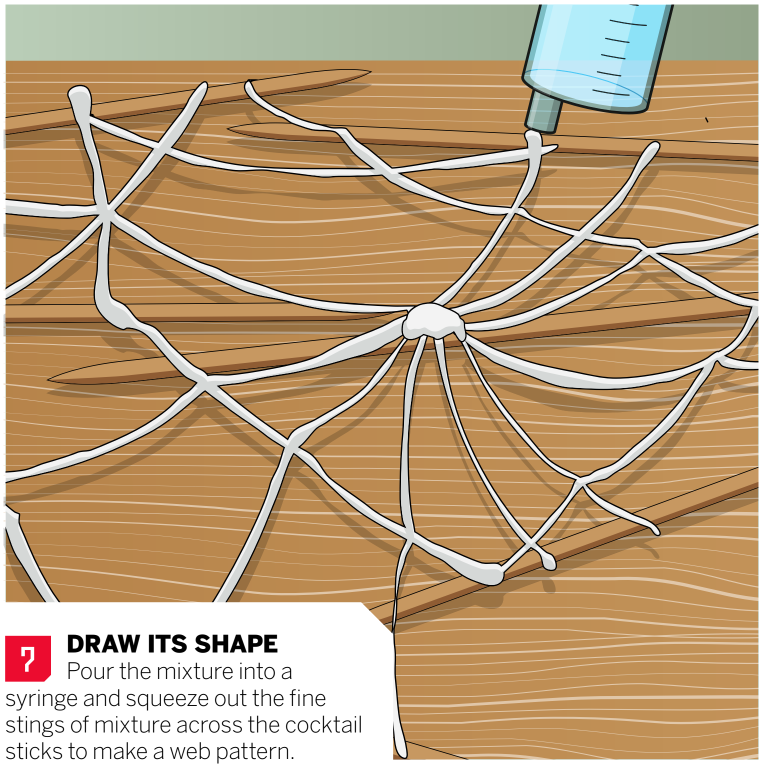
SEND YOUR IDEAS TO: HOW IT WORKS MAGAZINE @HOWITWORKSMAG HOWITWORKS@FUTURENET.COM HOWITWORKSMAG

DON'T DO IT ALONE!

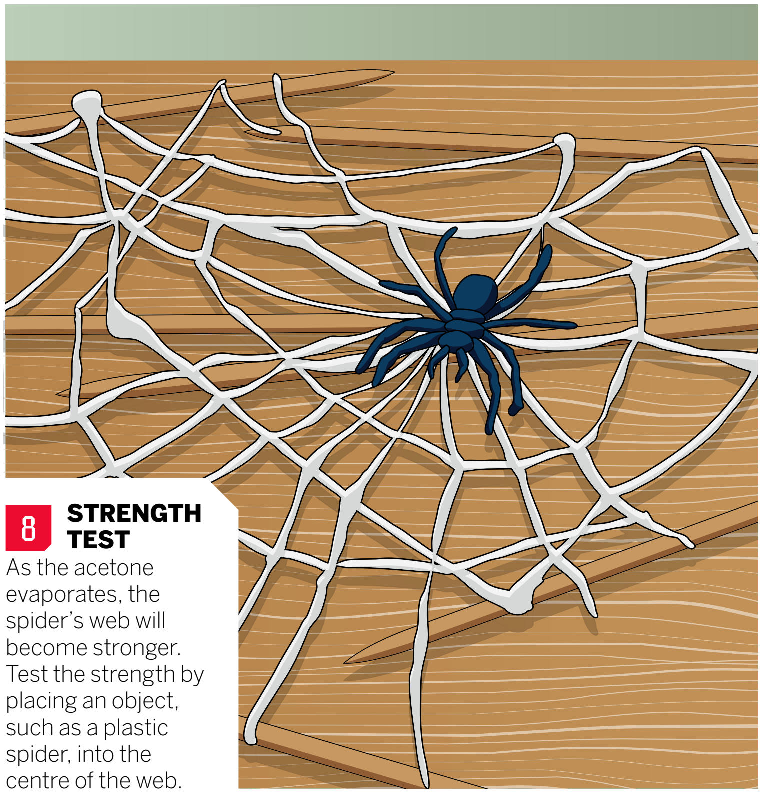
If you're under 16, make sure you have an adult with you

NEXT ISSUE

MAKE YOUR OWN ROBOTIC HAND



7 DRAW ITS SHAPE
Pour the mixture into a syringe and squeeze out the fine stings of mixture across the cocktail sticks to make a web pattern.



8 STRENGTH TEST
As the acetone evaporates, the spider's web will become stronger. Test the strength by placing an object, such as a plastic spider, into the centre of the web.

SUMMARY

The Styrofoam is made mostly of air, which is what makes it so light. This is how so much of it manages to disappear into the acetone nail polish. As the Styrofoam dissolves, all the trapped air is released. Styrofoam is made up of long polystyrene molecules, and when these molecules come in contact with the acetone, the liquid becomes extremely viscous. At the point that the mixture is ready to be used as a web, the polystyrene molecules are joined together in the liquid. Just as a real spider's web hardens soon after the silk is released from the spider, the acetone will evaporate to make your web design a solid one.

Had a go? Let us know!

If you've tried out any of our experiments – or conducted some of your own – let us know! Share your photos or videos with us on social media.

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INBOX

Speak your mind

SEND YOUR QUESTIONS OR COMMENTS TO: HOW IT WORKS MAGAZINE @HOWITWORKSMAG @HOWITWORKSMAG HOWITWORKS@FUTURENET.COM HOWITWORKSMAG

ADVERTISING TRICKS

Dear **HIW**,
How does the technology work to personalise the adverts you see on your phone? Sometimes I speak about something and don't search for it on my phone, but I still receive adverts for a specific product. Is there a way to stop this?
Mel Farrance

LETTER of the MONTH

It can be quite unnerving to come across targeted adverts and, like yourself, it often leaves people wondering how your phone gets hold of this information. Personalised adverts can be useful, as you are more likely to be interested in the products being presented to you. For this to happen, technology companies such as Google will collect data from internet searches, the types of sites you've visited, the location of your device and activity from downloaded applications.

Your phone also has the ability to listen to its surroundings for virtual assistants such as Siri to work. However, many platforms, such as Facebook, state that they don't allow companies to advertise on their sites using microphone-collected information. While today's technology does enable devices to be able to record and understand speech, this shouldn't be used without your consent. To avoid personalised adverts from appearing, you can take extra care to read the privacy terms. For example, whenever you enter a website or application and receive a notification with 'accept' or 'refuse', you should make sure you know what you are agreeing to. Sometimes this is in the form of a checkbox list that can help you reduce the methods used for targeted advertising.

Keywords in internet searches can trigger personalised adverts

WIN!

AN AMAZING PRIZE FOR LETTER OF THE MONTH

MEDICINE: A MAGNIFICENTLY ILLUSTRATED HISTORY

From potions and ointments to modern-day bionics, this strikingly illustrated book charts the history of medicine in engaging and unusual ways

AUTUMN ANSWERS

Dear **HIW**,
Autumn is my favourite season, and I was wondering what makes the autumn colours?
Nathaniel Mills

The two main pigment types that are visible in leaves are chlorophyll and carotenoids. Chlorophyll gives a green colour to leaves, mostly in spring and summer. This is the stronger pigment, preventing carotenoids from being seen. But chlorophyll needs to be replenished regularly, and nutrients are required to do so. During autumn and winter, the nutrients being transported to the leaves are blocked and the chlorophyll begins to fade. Instead, the yellow and orange carotenoids have their time to shine – at least until the leaves fall.

Animals, bacteria and fungi break down autumn leaves

QUESTIONING CLIMATE

Dear **HIW**,
The weather seems to be all over the place, but what country usually has the most diverse climate throughout the year?
Hannah Doyle

Most of Earth's climates can be experienced in China due to its area of 3,700,000 square miles. This gives the country a great range in latitude, longitude and mountainous land with diverse altitudes and temperatures. One climate event in China is monsoon rain. When winds blow from the north and south during winter and summer, high volumes of rain are carried and dropped over the country. For China's climate, one label doesn't fit all regions. Some may have intense rainfall while other regions are in the midst of a drought. During the coldest months, different parts of the country experience average lows of -40 degrees Celsius and highs of 40 degrees Celsius in the height of summer.

Monsoon season in China's southern cities is between April and September

NEXT ISSUE

ISSUE 171

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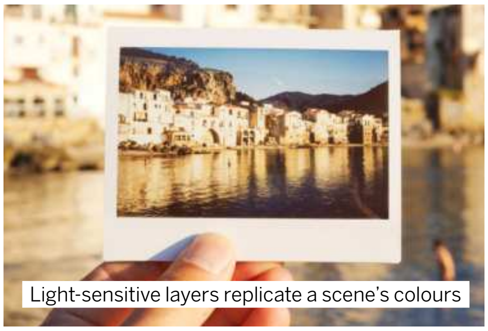
The bacteria in pickles can ease acid reflux

IN A PICKLE

Dear **HIW**,
I get indigestion quite often. I have found that if I eat a pickled gherkin, it's cured straight away. How does this work? I'd have thought stomach acid caused the problem and the acid in the pickle would have made it worse.
Stephen

You have stumbled across a very popular yet unexpected cure for indigestion. You are correct in your first statement that indigestion is often caused by stomach acid irritating the stomach lining. How pickles can work to fix this is to replenish the intestines and stomach with 'good' bacteria. Many people choose to drink pickle juice when suffering from indigestion, but eating pickles works too. The probiotic lactobacillus bacteria in pickles soothes and restores the lining of the stomach, helping to prevent further irritation.


Light-sensitive layers replicate a scene's colours

PICTURE PERFECT

Dear **HIW**,
Polaroid film is quite expensive. Why is this?
Kathy Forgia

The film for instant cameras is expensive as it needs to contain all the materials for any photograph you might choose to capture with film. To do this, layers of material need to rearrange to display the correct colours in precise areas. Polaroid film has light-sensitive layers that different dye developer molecules will diffuse through depending on the light wavelengths that enter the camera. While these are relatively expensive compared to other modern methods, many still choose this option due to the satisfaction of watching an image appear before them.

WE ASKED YOU

This month on social media, we asked you: What is your most memorable close encounter with an animal?

JENNIFER CHARLES

When I was walking in the forest a deer ran very close to me before getting scared

@MAIA_H3

Being very close to lions on a safari in Zimbabwe

THOMAS D

When I was scuba diving and saw a barracuda

JACKSON HILL

I once put my foot on a massive spider inside my shoe

SHELDON G

I was cycling along a country road when some cows escaped their field. There were around eight female cows running away from me, so I slowed down, but then another group of cyclists came the other way and they turned on me. As I cycled back the other way with the cows chasing me, a bull also escaped and ran at me from the other side. Luckily the cows found a wall to jump over and I could cycle away

© Getty

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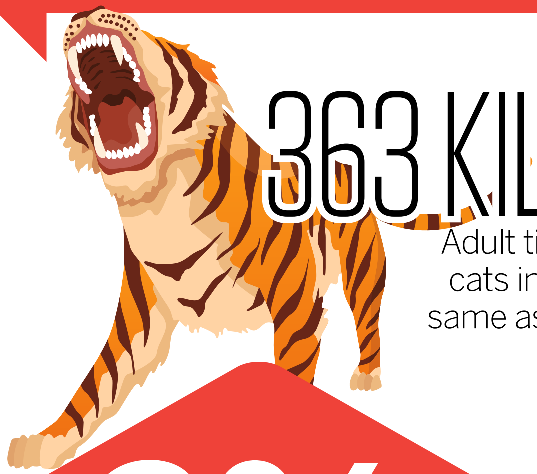
FAST FACTS

Amazing trivia that will blow your mind



363 KILOGRAMS

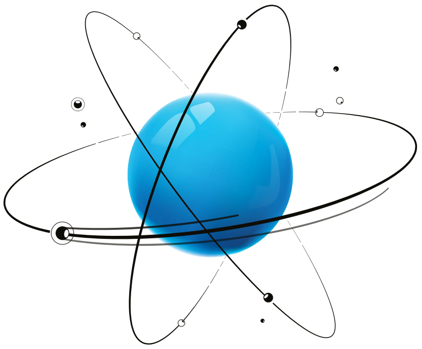
Adult tigers are the biggest wild cats in the world, weighing the same as ten ten-year-old children

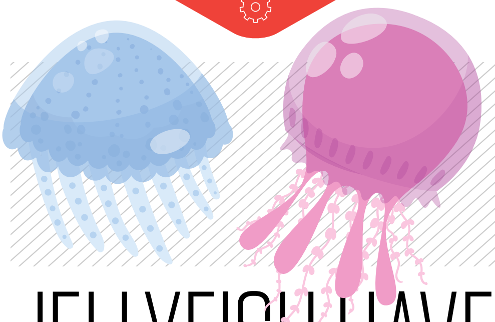
2%

What is visible in the universe accounts for a small fraction of its entire mass

99.999 99999 99999%

Most of an atom is completely empty space

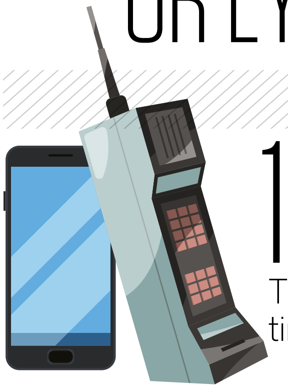




JELLYFISH HAVE NO BONES, BRAIN, HEART OR EYES

440 MILES

The trenches along World War I's Western Front stretched from the Belgian coast to Switzerland



1.1 KILOGRAMS

The first mobile phone weighed around five times more than the heaviest iPhone 13

18 CENTIMETRES

Fleas can jump over 100 times their length, the equivalent of a human jumping up 76 metres

753 BCE

Rome, one of the world's oldest cities, was founded nearly 3,000 years ago

IN QUANTUM PHYSICS, EVENTS IN THE FUTURE CAN AFFECT THE PAST

To reduce the chance of them both falling sick, pilots and copilots eat different in-flight meals

38 MILES PER HOUR

In some experiments, light has been recorded travelling just a bit faster than a Tour de France cyclist

LITTLE GIANTS VOLLEYBALL CLUB

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- Mains powered lower LED illumination with abbe condenser and iris diaphragm

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